DVD

TREVOR LINSLEY

Electrical Installation Work

TUTOR SUPPORT MATERIAL

Fully up-to-date with 17th Edition IEE Wiring Regs

SECOND EDITION

Level 2 & 3

City & Guilds 2330 Technical Certificate & 2356 NVQ

Newnes

Tutor Support Material

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Electrical Installation Work

2330 Certificate in Electrotechnical Technology (Levels 2 & 3)

SECOND EDITION

TREVOR LINSLEY

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Contents

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Preface

This Tutor Support Material (TSM) aims to provide worksheets and activities, with answers as an additional resource in support of the individual lecturer's delivery of the City & Guilds 2330 Syllabus in Electrotechnical Technology at both Level 2 and Level 3.

It has been designed to supplement and support the existing material used by lecturers to deliver the underpinning knowledge objectives of the curriculum. Handouts provide basic information in bullet point format. Worksheets provide opportunities for student activity, feedback of student understanding and reinforcement of knowledge gained. The TSM presentation follows closely the style and format of the City & Guilds Syllabus.

Each Unit concludes with Multiple Choice questions in preparation for the City & Guilds on-line assessment.

The complete TSM is provided as PDF files on the enclosed CD-ROM, available for printing within the purchasing institution (most of the images are provided in colour). The CD-ROM also includes all the figures from the related student textbooks *Basic Electrical Installation Work* 5th Edition (ISBN 9780750687515) and *Advanced Electrical Installation Work* 5th Edition (ISBN 9780750687522). These files can be incorporated into your own PowerPoint presentations for lecture delivery.

Trevor Linsley
2008

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I would like to acknowledge the assistance given by the following manufacturers and professional organizations in the preparation of this TSM:

- The Institution of Engineering and Technology for permission to reproduce Regulations and Tables from the IEE Regulations (17th Edition).
- The British Standards Institution for permission to reproduce Regulations and Tables from BS 7671: 2008.
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- RS Components Ltd., for technical information and photographs.
- Stocksigns Ltd., for technical information and photographs.
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I would like to thank the many college lecturers who responded to the questionnaire from Elsevier the publishers, regarding the proposed new edition of this book. Their recommendations relating to the content and style have been included in this improved 2nd Edition.

I would like to thank Jason Vann Smith MIET MIEEE MBCS MACM for the photographs used in the page design.

I would also like to thank the editorial and production staff at Elsevier the publishers, for their enthusiasm and support. They were able to publish this 2nd Edition within the very short time scale created by the publication of the 17th Edition of the IEE Regulations.

Finally, I would like to thank Joyce, Samantha and Victoria for their support and encouragement.

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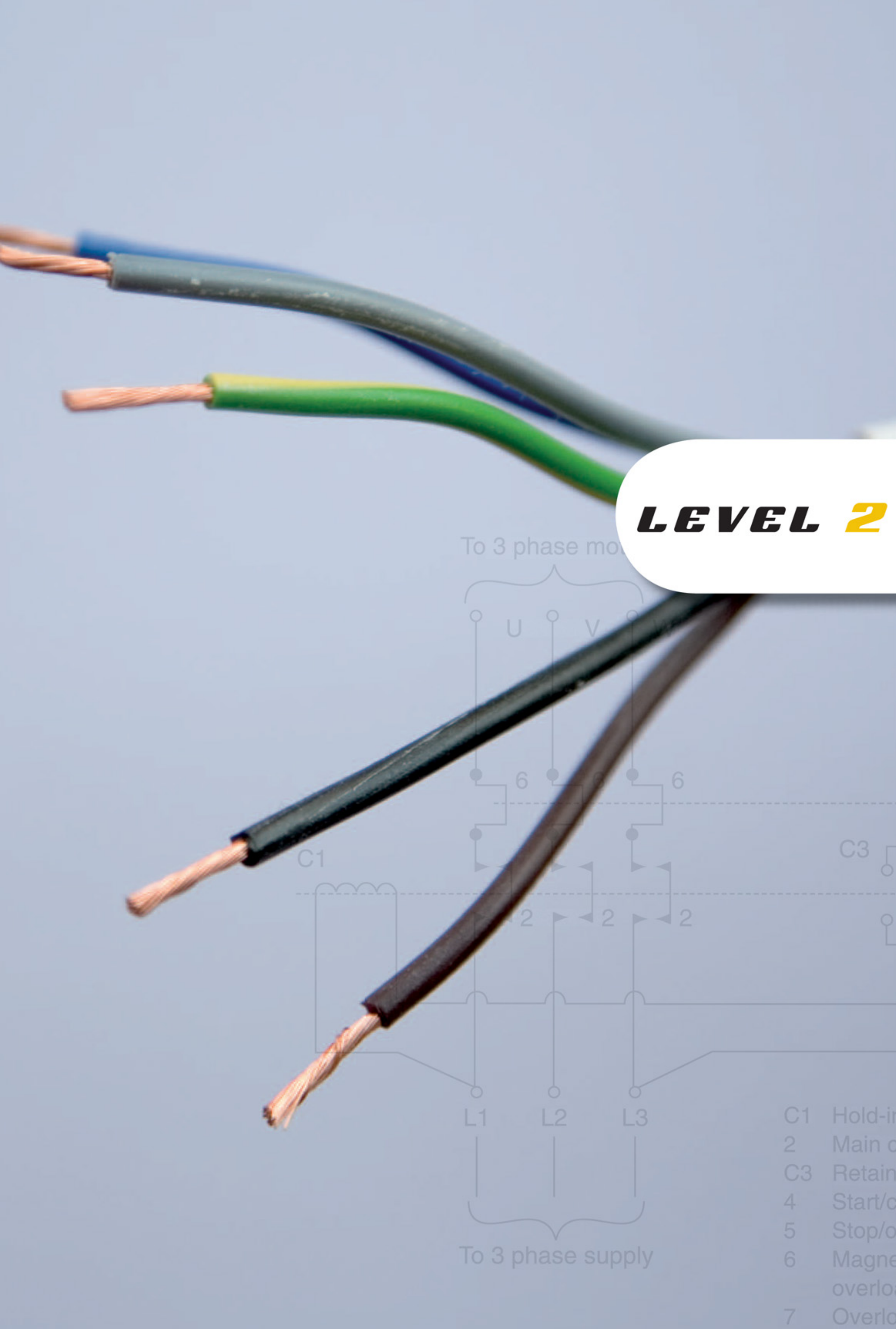

LEVEL 2

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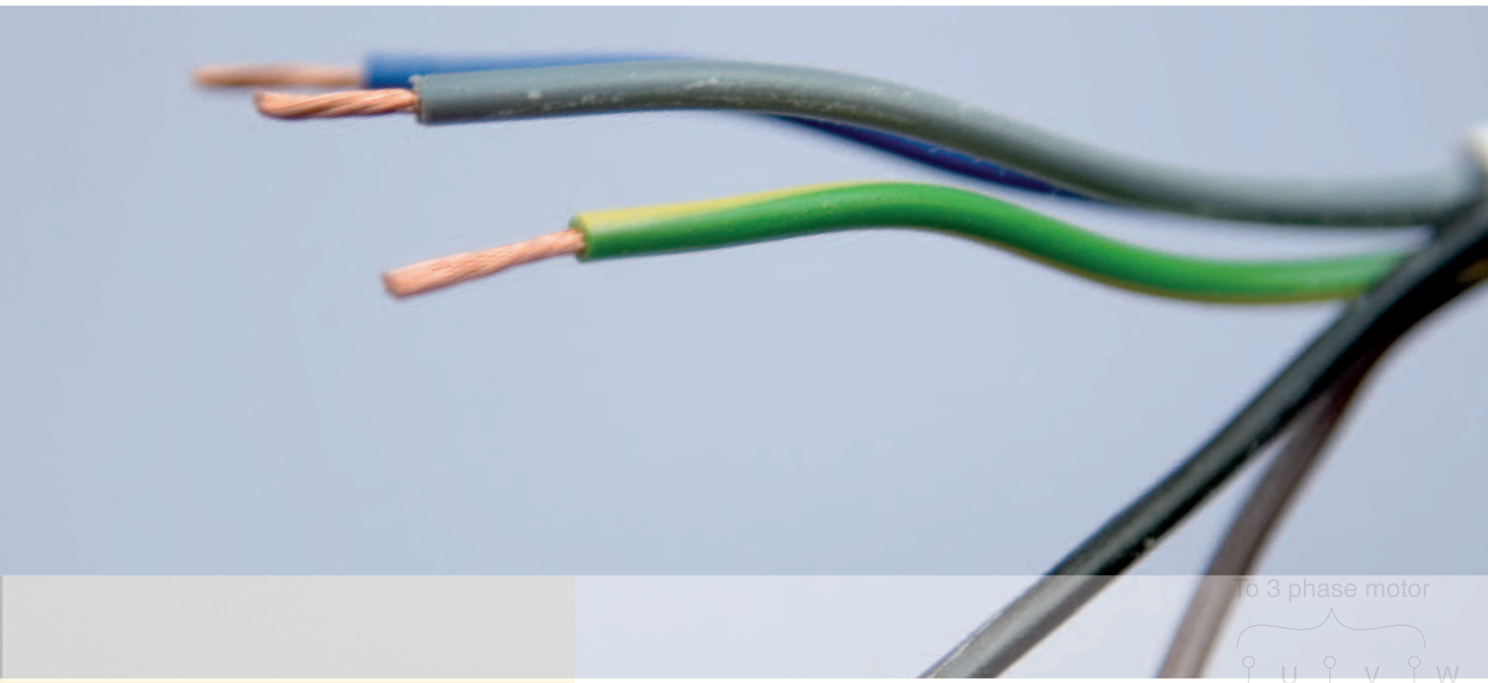
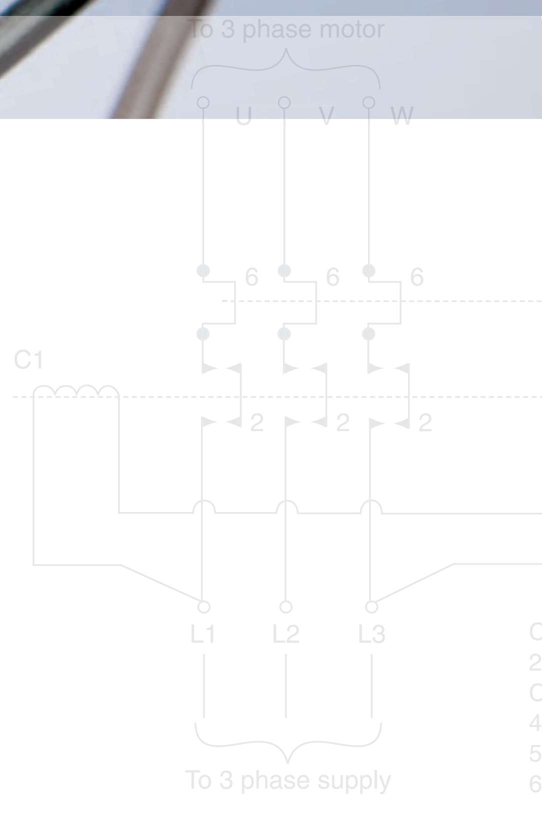
1

Core Unit 1, Level 2 Working Effectively and Safely in an Electrotechnical Environment (Stage 1)





Level 2 – Certificate in Electrotechnical Technology

Contents

Legal responsibilities within the Health and Safety at Work Act

The HSAWA makes everyone responsible for safety at work.

Employers have a Duty to:

- ensure that the working conditions and standards of hygiene are appropriate
- maintain plant, tools and equipment properly
- provide the necessary safety equipment such as personal protective equipment (PPE) dust and fume extraction and machine guards
- train workers to use equipment and plant safely
- undertake to ensure that precautions are taken against fire, provide adequate means of escape, and the means of fighting fire.

Employees (workers) have a Duty to:

- take care for their own health and safety and that of other workers who may be affected by their work activities
- co-operate with their employer to help him or her comply with the requirements of the Act
- not interfere with or misuse anything provided to protect health and safety.

Further information can be found on pages 4 to 6 of *Basic Electrical Installation Work* 5th edition, ISBN 9780750687515.

Legal responsibilities within the Health and Safety at Work Act

Employers have a Duty to:

- prepare a written Health and Safety Policy Statement and if the company employs more than five people, bring this to the attention of all employees (part 1 Section 3 of the Act)

A typical Health and Safety Policy Statement is shown in Fig. 1.1 below.

FLASH-BANG ELECTRICAL

Statement of Health and Safety at Work Policy in accordance with the Health and Safety at Work Act 1974

Company objective

The promotion of health and safety measures is a mutual objective for the Company and for its employees at all levels. It is the intention that all the Company's affairs will be conducted in a manner which will not cause risk to the health and safety of its members, employees or the general public. For this purpose it is the Company policy that the responsibility for health and safety at work will be divided between all the employees and the Company in the manner outlined below.

Company's responsibilities

The Company will, as a responsible employer, make every endeavour to meet its legal obligations under the Health and Safety at Work Act to ensure the health and safety of its employees and the general public. Particular attention will be paid to the provision of the following:

1. Plant equipment and systems of work that are safe.
2. Safe arrangements for the use, handling, storage and transport of articles, materials and substances.
3. Sufficient information, instruction, training and supervision to enable all employees to contribute positively to their own safety and health at work and to avoid hazards.
4. A safe place of work, and safe access to it.
5. A healthy working environment.
6. Adequate welfare services.

Note: Reference should be made to the appropriate safety etc. manuals.

Employees' responsibilities

Each employee is responsible for ensuring that the work which he/she undertakes is conducted in a manner which is safe to himself or herself, other members of the general public, and for obeying the advice and instructions on safety and health matters issued by his/her superior. If any employee considers that a hazard to health and safety exists it is his/her responsibility to report the matter to his/her supervisor or through his/her Union Representative or such other person as may be subsequently defined.

Management and Supervisors' responsibilities

Management and supervisors at all levels are expected to set an example in safe behaviour and maintain a constant and continuing interest in employee safety, in particular by:

1. acquiring the knowledge of health and safety regulations and codes of practice necessary to ensure the safety of employees in the workplace,
2. acquainting employees with these regulations on codes of practice and giving guidance on safety matters,
3. ensuring that employees act on instructions and advice given.

General Managers are ultimately responsible to the Company for the rectification or reporting of any safety hazard which is brought to their attention.

Joint consultations

Joint consultation on health and safety matters is important. The Company will agree with its staff, or their representatives, adequate arrangements for joint consultation on measures for promoting safety and health at work, and make and maintain satisfactory arrangements for the participation of their employees in the development and supervision of such measures. Trade Union representatives will initially be regarded as undertaking the role of Safety Representatives envisaged in the Health and Safety at Work Act. These representatives share a responsibility with management to ensure the health and safety of their members and are responsible for drawing the attention of management to any shortcomings in the Company's health and safety arrangements. The Company will in so far as is reasonably practicable provide representatives with facilities and training in order that they may carry out this task.

Review

A review, addition or modification of this statement may be made at any time and may be supplemented as appropriate by further statements relating to the work of particular departments and in accordance with any new regulations or codes of practice.

This policy statement will be brought to the attention of all employees.

FIGURE 1.1

Typical Health and Safety Policy Statement.

Health and safety

State the responsibilities under the Health and Safety at Work Act of both Employers and Employees

Arrange the responsibilities written below under the two headings given in the table over page. The first two have been done for you in order to get you going.

Create safe working conditions

Do not misuse safety equipment

Work safely

Put up safety signs

Care for others' safety

Wear a hard hat in a "hard hat" area

Maintain equipment

Prepare a Health and Safety Policy Statement

Fit machine guards

Provide adequate welfare facilities

Install fume extractors

Provide adequate first aid facilities

Provide PPE

Provide fire fighting equipment

Wear PPE

Provide means of escape from fire

Provide safety training

See a first aider with minor cuts

Attend safety training courses

Report certain injuries, diseases and dangerous occurrences

Co-operate with employee

Complete an accident/first aid report following minor injuries

Do not damage safety equipment

Employers' Responsibilities	Employees' Responsibilities
Create safe working conditions	*Work safely*

Statutory laws

Acts of Parliament are made up of statutes. Statutory laws and regulations have been passed by Parliament and have therefore become laws. The syllabus requires that we look at seven statutory regulations.

1. **The Health and Safety At Work Act 1974**
   - The purpose of the HSAWA is to provide the legal framework for stimulating and encouraging high standards of health and safety at work.
   - The Act places the responsibility for safety at work on **both** workers and employers.
   - The HSAWA is an "Enabling Act" which allows the Secretary of State to make further regulations and modify existing regulations to create a safe working environment without the need to pass another Act of Parliament.
2. **Electricity at Work Regulations 1989**
   - These regulations are made under the Health and Safety at Work Act and are enforced by the Health and Safety Executive (HSE).
   - The purpose of the regulations is to "require precautions to be taken against the risk of death or personal injury from electricity in work activities".
   - An electrical installation wired in accordance with the IEE Regulations BS 7671 will also meet the requirements of the Electricity and Work Regulations (EWR).
3. **The Electricity Safety, Quality and Continuity Regulations 2002**
   - These regulations are designed to ensure a proper and safe supply of electrical energy up to the consumers' mains electrical intake position.
   - They will not normally concern the electrical contractor, except in that it is these regulations which set out the earthing requirements of the supply.
4. **The Management of Health and Safety at Work Regulations 1999**
   - To comply with the Health and Safety at Work Act 1974, employers must have "robust Health and Safety systems and procedures in the workplace".
   - Employers must "systematically examine the workplace, the work activity and the management of safety through a process of risk assessment".
   - Information based upon the risk assessment findings must be communicated to relevant staff.
   - So, risk assessment must form a part of any employers' "robust policy of Health and Safety".
5. **Provision and Use of Work Equipment Regulations 1998**
   - These regulations place a general duty of care upon employers to ensure minimum requirements of plant and equipment used in work activities.
   - If an employer has purchased good quality plant and equipment, and that plant and equipment is well maintained, there is little else to do.
6. **COSHH Regulations (2002)**
   - The Control of Substances Hazardous to Health (COSHH) Regulations control people's exposure to hazardous substances in the workplace.
   - Employers must carry out risk assessments and, where necessary, provide PPE so that employees will not endanger themselves.
   - Employees must also receive information and training in the safe storage, disposal and emergency procedures which are to be followed by anyone using hazardous substances.
7. **Personal Protective Equipment (PPE) Regulations**
   - PPE is defined as all equipment designed to be worn or held in order to protect against a risk to health and safety.
   - This includes most types of protective clothing and equipment such as eye, foot and head protection, safety harnesses, life jackets and high visibility clothing.
   - Employers must provide PPE free of charge and employees must make use of it for their protection.

Further information can be found on pages 4 to 14 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Non-statutory regulations

Statute Law is law which has been laid down by Parliament as Acts of Parliament.

Non-statutory regulations and codes of practice interpret the statutory regulations.

Non-statutory **does not** mean non-compulsory. If the non-statutory regulation is relevant to your part of the electrotechnical industry then you **must** comply.

The syllabus requires us to look at only one non-statutory regulation, the IEE Regulations.

The IEE Wiring Regulations, the Requirements for Electrical Installations (BS 7671: 2008)

1-10

- The IEE Wiring Regulations relate principally to the design, selection, erection, inspection and testing of electrical installations.

- We are currently using the 17th Edition: 2008.

- They apply:
  - to permanent or temporary installations
  - in and about buildings generally
  - to agricultural and horticultural premises
  - to construction sites
  - to caravans and caravan sites.

- They are the electrician's bible and provide an authoritative framework for all work activities undertaken by electricians.

- If your work meets the requirements of the IEE Regulations, it will also comply with the statutory regulations.

Further information can be found on pages xx and xx of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Regulations

Identify from the list below those regulations which are statutory and those which are non-statutory and state very briefly what that regulation controls. I will do the first one to get you going.

Regulation	*Statutory/Non-statutory*
1. COSHH Regulations	• Statutory Regs • Controls people's exposure to hazardous substances
2. Electricity at Work Regulations	
3. Health and Safety at Work Regulations	
4. IEE Wiring Regulations	
5. Management of Health and Safety at Work Regulations	
6. Personal Protective Equipment (PPE)	
7. Provision and Use of Work Equipment Regulations	
8. The Electricity Safety, Quality and Continuity Regulations	

Safety signs

Safety signs are displayed in the working environment to inform workers of the rules and regulations especially relevant to a particular section of the workplace.

They inform and give warning of possible danger and must be obeyed.

There are **four types** of safety signs:

1. Warning signs
2. Advisory signs
3. Mandatory signs
4. Prohibition signs

1. Warning Signs (For Safety Information)

These are triangular yellow signs with a black border and symbol as shown in Fig. 1.2. They give a warning of a hazard.

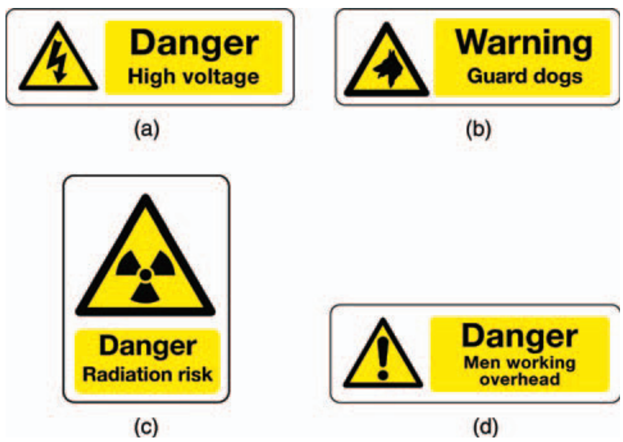


FIGURE 1.2
Warning signs.

2. Advisory Signs (For Safety Information)

Advisory or safe condition signs are square or rectangular green signs with a white symbol as shown in Fig. 1.3. They give information about safety provision.

FIGURE 1.3
Advisory or safe condition signs.

3. Mandatory Signs (You MUST DO Signs)

These are circular blue signs with a white symbol as shown in Fig. 1.4. They give instructions which must be obeyed.

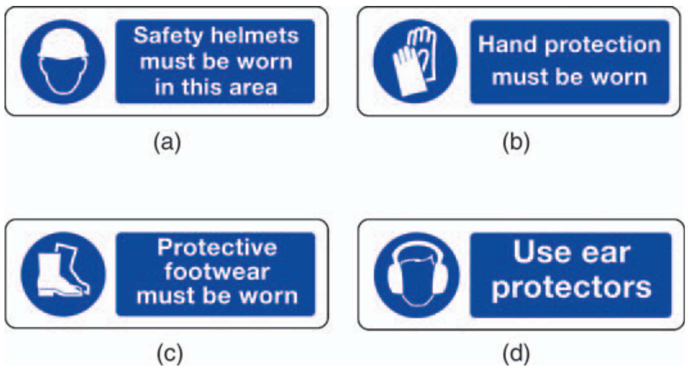


FIGURE 1.4
Mandatory signs.

4. Prohibition Signs (You MUST NOT DO Signs)

These are circular white signs with a red border and red cross bar as shown in Fig. 1.5. They indicate an activity which **must not** be carried out.

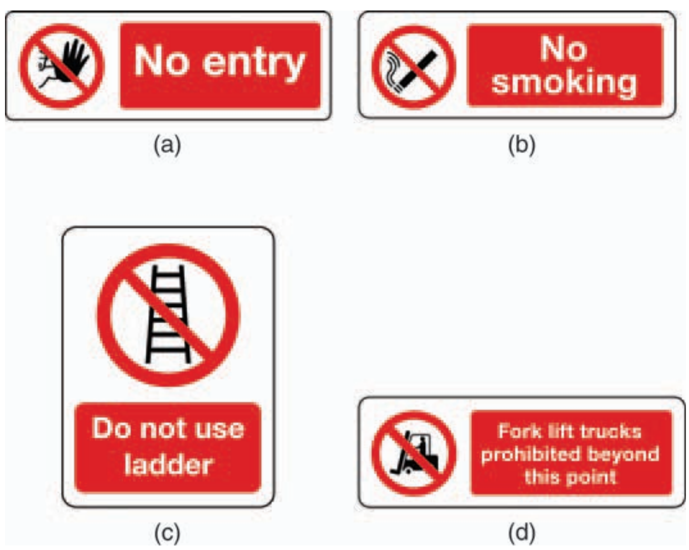


FIGURE 1.5
Prohibition signs.

Further information can be found on pages 22 to 24 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Safety signs

Identify the meaning of each of the signs shown on the next page in Fig. 1.6 and select the appropriate meaning from those listed below. For example, **number 1 = G**

A = Break glass for key to door

B = Dangerous chemicals

C = Do not drink this water

D = Do not use mobile phones

E = Emergency exit – this way

F = Fire assembly

G = Fork lift trucks operate here

H = Lift correctly

I = No access beyond this point

J = No dogs

K = Life jackets to be worn

L = Slippery surface

M = Tripping hazardous

N = Turn to operate safety door

O = Wear face mask

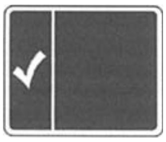
P = Wear goggles


1 =


2 =


3 =


4 =


5 =


6 =


7 =


8 =


9 =


10 =


11 =


12 =


13 =


14 =


15 =


16 =

FIGURE 1.6
Safety signs worksheet.
Source: Stocksigns LTD.

Personal protective equipment

- PPE is defined as all equipment designed to be worn, or held, to protect against a risk to health and safety.
- Employers must provide, free of charge, any personal protective equipment and employees must make full and proper use of it.
- The vulnerable parts of the body which may need protection are the head, eyes, ears, lungs, torso, hands and feet. Additionally, protection from falls may need to be considered.
- Objects falling from a height present the major hazard against which head protection is provided.

Safety signs such as those shown at Fig. 1.7 are useful reminders of the type of PPE to be used in a particular area.

FIGURE 1.7
Safety signs showing type of PPE to be worn.

Further information can be found on pages 12 to 14 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Personal protective equipment

PPE gives protection to different parts of the body, e.g. **hands**, **eyes**, **head**, and **feet**. On the worksheet over the page, list the type of PPE which gives protection to the relevant parts of the body from the list below.

Armlets

Boiler suit

Breathing apparatus

Bump caps

Cape hoods

Chemical suits

Conventional or disposable overalls

Disposable respirators

Donkey jackets

Earplugs

Face screens

Fresh air hose equipment

Full face respirators

Gaiters

Gauntlets

Gloves

Goggles

Half masks

Helmets

High visibility clothing

Leggings

Mitts

Muffs

Powered respirators

Safety boots, shoes, trainers

Safety harness

Sou'westers

Spats and clogs

Spectacles

Thermal clothing

Warehouse coats

Wrist cuffs

Personal protective equipment

Type of Protection	*Type of PPE*
Eyes	
Head and neck	
Ears	
Hands and arms	
Feet and legs	
Lungs	
Whole body	

Accident and emergency procedures

Despite new legislation, improved information, education and training, accidents at work do still happen.

- An accident may be defined as any uncontrolled event causing injury or damage to an individual or property.

- Make sure that even small accidents at work are recorded in the first aid/accident report book.

To avoid having an accident you should:

1. recognize situations which could lead to an accident and avoid them

2. follow your company's safety procedures – for example, fit safety signs when isolating electricity supplies and screen off work areas from the general public

3. not misuse or interfere with equipment provided to protect health and safety

4. dress appropriately and use PPE when necessary

5. behave appropriately and with care

6. stay alert and avoid fatigue

7. always work within your level of competence

8. take a positive decision to act and work safely. A simple accident may prevent you from working or following your favourite sport or hobby.

Further information can be found on pages 24 and 25 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Accident and emergency procedures

1. List below **eight** actions you could take to avoid having an accident at work

1. ....

2. ....

3. ....

4. ....

5. ....

6. ....

7. ....

8. ....

2. List **three** things that you must do following a minor injury/accident to yourself at work

   1. . . . .

   2. . . . .

   3. . . . .

3. Where are the first aid boxes located in your employment?

   Answer . . . .

   . . . .

4. List **two** things you would do if you see a dangerous or hazardous situation at work

   Answer 1 . . . .

   . . . .

   Answer 2 . . . .

   . . . .

1-21

Further information can be found on pages 24 and 25 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Emergency procedure – fire control

Fires in industry damage property and materials, injure people and sometimes cause loss of life. Everyone should make an effort to prevent fires, but those which do break out should be extinguished as quickly as possible.

In the event of a fire, you should:

- raise the alarm
- turn off machinery, gas and electricity supplies in the area of the fire
- close doors and windows but without locking or bolting them
- remove combustible material away from the path of the fire if this can be done safely
- attack small fires with the correct extinguisher.

Only attack the fire if you can do so without endangering your own safety in any way.

Fires are divided into four classes or categories:

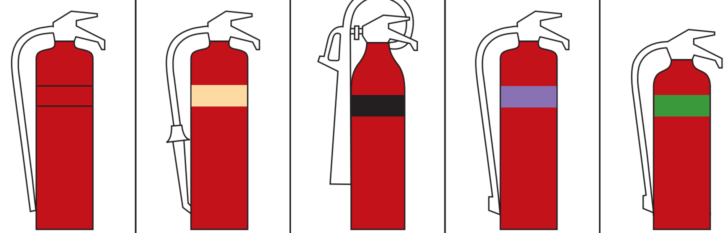
- Class A are wood, paper and textile fires
- Class B are liquid fires such as paint, petrol and oil
- Class C are fires involving gas or spilled liquefied gas
- Class D are very special types of fire involving burning metal.

Electrical fires do not have a special category because, once started, they can be identified as one of the four above types.

Fire extinguishers are for dealing with small fires, and different types of fire must be attacked with a different type of extinguisher.

Further information can be found on pages 25 to 27 in *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Figure 1.8 shows the correct type of extinguisher to be used on the various categories of fire. The colour coding shown is in accordance with BS EN3: 1996.



Type of fire extinguisher / Type of fire	(i) Water Signal red flash on red	(ii) Foam Pale cream flash on red	(iii) Carbon dioxide gas Black flash on red	(iv) Dry powder French blue flash on red	(v) Vapourizing foam Emerald green flash on red
Class A. Paper, wood and fabric	Yes	Yes	No	Yes	Yes
Class B. Flammable liquids	No	Yes	Yes	Yes	Yes
Class C. Flammable gases	No	No	Yes	Yes	Yes
Electrical fires	No	No	Yes	Yes	Yes
Motor vehicle protection	No	Yes	No	Yes	Yes

FIGURE 1.8

Fire extinguishers and their applications (colour codes to BS EN3: 1996). The base colour of all fire extinguishers is red, with a different coloured flash to indicate the type.

Further information can be found on pages 25 to 27 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Emergency procedure – fire control

Complete the table below

Type of fire extinguisher	*Colour code*	*Applications – to be used on*
Water		
Dry powder		
Foam		
Vapourizing foam		
Carbon dioxide gas		

Emergency procedure – electric shock

- Electric shock occurs when a person becomes part of the electrical circuit as shown in Fig. 1.9.
- The level or intensity of the shock will depend upon many factors, such as age, fitness and the circumstances in which the shock is received.
- The lethal level is approximately 50 mA, above which muscles contract, the heart flutters and breathing stops.
- Below 50 mA only an unpleasant tingling sensation may be experienced or you may feel like you have been hit in the chest.

To prevent people receiving an electric shock accidentally, all circuits must contain protective devices and all exposed metal must be earthed.

All circuits must be isolated before any work is carried out.

Actions to be taken upon finding a workmate receiving an electric shock are as follows:

- Switch off the supply if possible.
- Alternatively, remove person from the supply ***without touching him***.
- If breathing or heart has stopped, immediately call professional help by dialling 999 or 112 and asking for the ambulance service. Give precise directions to the scene of the accident. The casualty stands the best chance of survival if the emergency services can get a rapid response paramedic team quickly to the scene. They have extensive training and will have specialist equipment with them.
- Only then should you apply resuscitation or cardiac massage until the patient recovers or help arrives.

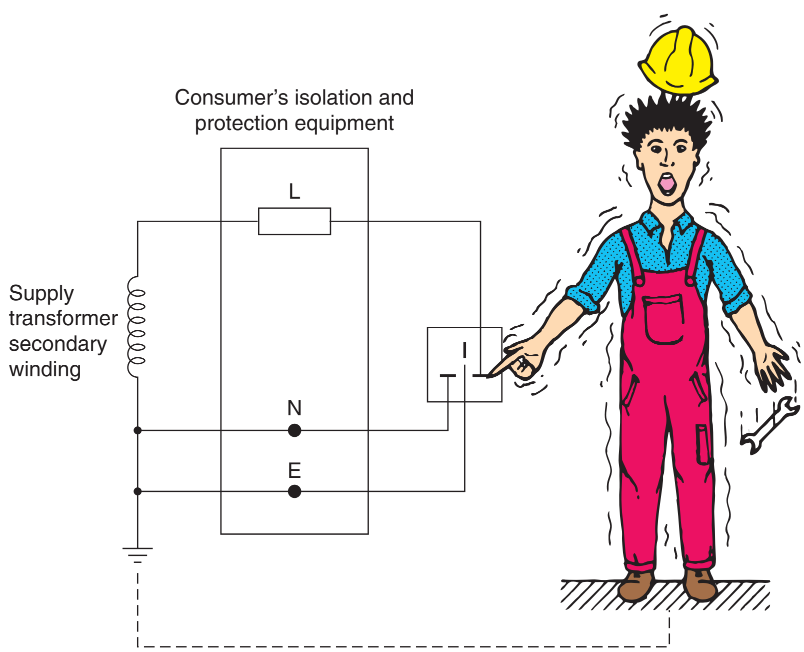


FIGURE 1.9
Electric shock touching live and earth or live and neutral makes a person part of the electrical circuit and can lead to an electric shock.

Further information can be found on pages 29 to 34 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Emergency procedure – electric shock

1. Use bullet points to describe the actions you would take upon finding a workmate receiving an electric shock.

   - ....
   - ....
   - ....
   - ....

2. Very briefly describe **three** occasions when you or a workmate have received an electric shock.

   1. ....
   2. ....
   3. ....

3. Describe or use a sketch to show how you might become a part of an electrical circuit and receive an electric shock.

Further information can be found on pages 29 to 34 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Services provided by the electrotechnical industry

Lighting and power installations ensure that the building:

- is illuminated to an appropriate level
- is heated to a comfortable level
- has the power circuits to drive electrical and electronic equipment.

Emergency lighting and security systems ensure that the building:

- is safe to use in unforeseen or adverse situations
- is secure from unwanted intruders.

Building management and control systems provide a:

- controlled environment for the people who use commercial buildings
- pleasant environment so that people can work effectively and efficiently.

Instrumentation allows us to:

- safely monitor industrial processes and systems.

Electrical maintenance allows us to:

- maintain the efficiency of all installed systems.

Live cable jointing:

- provides a means of connecting new installations and services to existing live supply cables without inconvenience to existing supplies caused by electrical shutdown.

Highway electrical systems:

- make our roads and pavements safe for vehicles and pedestrians.

Electrical panel building provides a means of:

- electrical isolation and protection
- monitoring and measuring electrical systems in our commercial and industrial buildings.

Electrical machine drive installations:

- drive everything that makes our modern life comfortable from trains and trams to lifts and air conditioning units.

Consumer and commercial electronics give us:

- data processing and number crunching
- electronic mail and access to information on the world wide web
- access to high quality audio and video systems.

Further information can be found on pages 44 and 45 *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Services provided by the electrotechnical industry

In just a few words identify the service provided by the following specialisms within the electrotechnical industry

Specialism	*Service provided*
Building management systems	
Cable jointing	
Computer installations	
Control systems	
Commercial electronics	
Data cabling	
Electrical maintenance	
Electrical machine drives	
Emergency power	
Fibre optics	
Highway electrical systems	
Instrumentation	
Lighting installations	
Panel building	
Power installations	
Security alarms/systems	

Organizations having electrotechnical activities

(a) **Electrical contractors**

- The focus of this type of organization is on all types of electrotechnical activities. They:
  - install electrical equipment
  - install electrical systems
  - carry out their installation work in domestic, commercial and industrial buildings.

(b) **Factories**

- Contain lots of electrical plant and equipment. The wheels of all types of industry are driven by electrotechnical activities.

(c) **Process plants**

- Whether they process food or nuclear fuels, the prime mover for all processes is electrical plant, control and instrumentation equipment and machine drives.

(d) **Local councils**

- Responsible for many different types of community buildings from Town Halls to swimming pools. The buildings all have electrical systems which require installation, maintenance and repair.

(e) **Commercial buildings and complexes**

- The "office type" activities carried out in these buildings require that electrical communication and data transmission systems are installed, maintained and repaired.

(f) **Leisure centres**

- These types of buildings contain lots of equipment driven by human sweat but which is also controlled and monitored by electrical and electronic equipment. They might contain a swimming pool or a "hot air" sauna. Both types of electrical installation are considered "special installations" by the IEE Regulations: BS 7671.

(g) **Panel builders**

- Build specialist control, protection and isolation main switchgear systems for commerce and industry. The panel incorporates the isolation and protection systems required by the electrical installation.

(h) **Motor re-wind and repair**

- Electrical motors and their drives usually form an integral part of the industrial system or process.
  - Electrical motors and transformers sometimes break down or burn out
  - An exact new replacement can often be quickly installed
  - Alternatively, the existing motor can be re-wound and reconditioned if time permits.

(i) **Railways**

- The prime mover for a modern inter-city type electric train is an electric motor.
  - Electric trains require an infrastructure of electrical transmission lines throughout the network
  - All rail movements require signal and control systems
  - Railway station buildings contain electrical and electronic installations.

(j) **The Armed Forces**

- Operate in harsh, hostile and unpredictable environments.
  - They need to adapt, modify and repair electrical and electronic systems in a war situation away from their home base and a comfortable well-equipped workshop
  - A modern warship can contain as many people as an English village. They need electrotechnical systems to support them and to keep them safe 24 hours per day, 7 days per week.

(k) **Hospitals**

- Contain a great deal of high-technology equipment.
  - This equipment requires power and electronic systems
  - Life monitoring equipment must continue to operate in a power failure
  - Standby electrical supplies are often an important part of a hospital's electrical installations.

(l) **Equipment and machine manufacturers**

- White goods, brown goods, computer hardware, motors and transformers are manufactured to meet the increasing demands of the domestic, commercial and industrial markets.
  - They are manufactured to very high standards and often contain very sophisticated electrical and electronic circuits and systems
  - They manufacture to British and European Standards.

Further information can be found on pages 42 and 44 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Organizations having electrotechnical activities

Identify the electrotechnical activities carried out by three different organizations known to you. You might like to start with the organization or company that you work for.

Organization 1 **Type of Organization** ....

Electrotechnical activities carried out by that organization

- ....
- ....
- ....
- ....

Organization 2 **Type of Organization** ....

Electrotechnical activities carried out by that organization

- ....
- ....
- ....
- ....

Organization 3 **Type of Organization** ....

Electrotechnical activities carried out by that organization

- ....
- ....
- ....
- ....

Roles and responsibilities of workers in the electrotechnical industry

Any electrotechnical organization is made up of a group of individuals with various duties, all working together for their own good, the good of their employer, and their customers.

There is often no clear distinction between the duties of the individual employees; each does some of the others' work activities.

Responsibilities vary, even by people holding the same job title.

Some individuals hold more than one job title.

Design engineer

- Will normally meet with clients and other trade professionals to interpret the customer's requirements
- Will produce the design specification which enables the cost of the project to be estimated.

Estimator/cost engineer

- Measures the quantities of labour and material necessary to complete the electrical project
- From these calculations and the company's fixed costs, a project cost can be agreed.

Contracts manager

- May oversee a number of electrical contracts on different sites
- Will monitor progress in consultation with the project manager on behalf of the electrical company
- Will cost out variations to the initial contract
- May have Health and Safety responsibilities because he or she has an overview of all company employees and contracts in progress.

Project manager

- Is responsible for the day-to-day management of one specific contractor
- Will have overall responsibility on that site for the whole electrical installation
- Attends site meetings with other trades as the representative of the electrical contractor.

Service manager

- Monitors the quality of the service delivered under the terms of the contract
- Checks that the contract targets are being met
- Checks that the customer is satisfied with all aspects of the project
- The service manager's focus is customer specific while the project manager's focus is job specific.

Technicians

- Will be more office based than site based
- Carry out surveys of electrical systems
- Update electrical drawings
- Obtain quotations from suppliers
- Maintain records such as ISO 9000 quality systems
- Carry out testing inspections and commissioning of electrical installations
- Trouble shoot.

Supervisor/foreman

- Will probably be a mature electrician
- Have responsibility for small contracts
- Have responsibility for a small part of a large contract
- Be the leader of a small team (e.g. electrician and trainee) installing electrical systems.

Operative

- Will carry out the electrical work under the direction and guidance of a supervisor
- Will demonstrate a high degree of skill and competence in electrical work
- Will have, or be working towards, a recognized electrical qualification and status as an electrician, approved electrician or electrical technician.

Mechanic/fitter

- Is an operative who usually has a "core skill" or "basic skill" and qualification in mechanical rather than electrical engineering
- In production and process work the mechanic/fitter would have responsibility for the engineering and fitting aspects of the contract, while the electrician and instrumentation technician would take care of the electrical and instrumentation aspects
- All three operatives must work closely in production and process work
- "Additional skilling" or "multi-skilling" training produces a more flexible operative for production and process plant operations.

Maintenance manager/engineer

- Is responsible for keeping the installed electrotechnical plant and equipment working efficiently
- Takes over from the builders and contractors the responsibility of maintaining all plant equipment and systems under their control
- Might be responsible for a hospital or a commercial building, a university or college complex
- Will set up routine and preventative maintenance programmes to reduce breakdowns
- When faults or breakdowns do occur, the maintenance manager/engineer will be responsible for the repair using the company's maintenance staff.

Further information can be found on pages 45 to 50 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Roles and responsibilities of workers in the electrotechnical industry

Part A:

In this worksheet, I want you to consider what people do (their roles and responsibilities) in the company that you work for.

In general terms, the structure of a company may be thought of as having the shape of a triangle or pyramid. In this model, the owner or managing director would be at the top and the electricians and trainees at the bottom. There will be a number of electricians and trainees but only one owner or managing director.

So, what is your job title? (Apprentice–Trainee) ....

and what are your responsibilities?..

....

Who is your supervisor?..

What is your supervisor's job title? (Electrician–Approved Electrician–Foreman) ....

and what are their responsibilities? ....

....

Who is your supervisor's line manager? ....

What is their job title? (Supervisor–Foreman–Project Manager) ....

and what are their responsibilities? ....

....

Who is the line manager of the person named above? ....

What is their job title? (Contracts Manager–Managing Director) ....

and what are their responsibilities? ....

....

Part B:

Throughout this unit, we will look at the regulations as they apply to the electrotechnical industry. These Regulations make numerous references to people who are "competent", "instructed", "ordinary" or "skilled" people.

In this worksheet, I want you to bring together some of these important definitions.

An ordinary person is ....

....

....

A competent person is ....

....

....

An instructed person is ....

....

....

A skilled person is ....

....

....

Further information can be found on page 53 of *Basic Electrical Installation Work* 5th, Edition. ISBN 9780750687515.

Professional bodies supporting electrotechnical organizations

The IEE (The institution of Electrical Engineers)

- The IEE was established in 1871. The IEE and the Institution of Incorporated Engineers formed a new organization, the **Institution of Engineering and Technology**, the IET on 31 March 2006 to become the largest professional engineering society in Europe with 150,000 members.
- The IEE produce the Wiring Regulations to BS 7671.
- They also produce many other publications and provide training courses to help electricians, managers and supervisors to keep up-to-date with the changes in the relevant regulations.
- *The On Site Guide* describes the "requirements for electrical installations".
- Eight guidance notebooks are available.
- *The Electricians Guide to the Building Regulations* clarifies the requirements for electrical operatives of the new Part P Regulations which came into effect from 1 January 2005.
- *Wiring Matters* is a quarterly magazine published by the IET covering many of the topics which may trouble some of us in the electrotechnical industries.
- All of these publications can be purchased by visiting the IET website at www.theiet.org/shop or Email: sales@theiet.org

The ECA (Electrical Contractors Association)

- The ECA was founded over 100 years ago and is a Trade Association representing electrotechnical companies.
- Membership is made up of electrical contracting companies both large and small.
- Customers employing an electrical contractor who has ECA membership are guaranteed that the work undertaken will meet all relevant regulations.
- The work of the ECA member is regularly assessed by the Association's UKAS accredited inspection body.
- Further information can be found at the ECA website at www.eca.co.uk

NICEIC (The National Inspection Council for Electrical Installation Contracting)

- The NICEIC is an independent consumer safety organization, set up to protect users of electricity against the hazards of unsafe electrical installations.
- It is the electrical industry's safety regulatory body.
- The NICEIC publishes a list of Approved Contractors whose standard of work is regularly assessed by local area engineers.
- Further information can be found at www.niceic.org.uk

Trade Unions

- Trade Unions represent workers.
- They negotiate the pay and working conditions of their members with employer organizations.
- The Trade Union which represents employees in the electrotechnical industry in the new millennium is called Amicus.
- Further information can be found at www.amicustheunion.org

Further information can be found on pages 54 to 56 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Professional bodies supporting electrotechnical organizations

1. Identify two professional/trade associations which support your part of the electrotechnical industry

   1. .... (name of association)

   2. .... (name of association)

   Does your employer belong to any of these associations? Yes/No

2. What **do you think** are the advantages of an employer being a member of a professional or trade association?

   - .... • ....
   - .... • ....

3. What is the name of the Trade Union which represents workers in your industry?

   - ....

   Are you a member? Yes/No Are your workmates members? Yes/No

4. What do you and your workmates think are the advantages or disadvantages of belonging to the Trade Union?

Advantages	Disadvantages
• For example member discounts................	• ....
•	• ....
•	• ....
•	• ....
•	• ....
•	• ....
•	• ....
•	• ....
•	• ....
•	• ....
•	• ....

Sources of technical information

From the work done so far in this unit, you will have realized that there are many people involved in any electrotechnical project.

For them all to work together toward a successful conclusion in the agreed timescale they have to find a way of effectively communicating technical information to each other.

Types of technical information

- Sketches, drawings and diagrams
- British Standards (BSI)
- Harmonized European Standards (BSEN)
- Codes of Practice
- Manufacturers' Instruction Manuals and leaflets
- Manufacturers' Catalogues
- Charts and Tables.

This information is available from

- Her Majesty's Stationery Office (HMSO)
- Manufacturers of electrical goods
- The British Standards Institute (BSI)
- Trade associations (ECA, NICEIC)
- Wholesalers of electrotechnical equipment
- The Institute of Electrical Engineers (IEE)

This information may be obtained and distributed in many forms

- Hard copy
- Books and booklets
- Microfilm
- CD-Rom
- Electronically downloaded from the Internet
- Email
- Fax machine.

Communications in the electrotechnical industries

Workers in the electrotechnical industries communicate with each other by means of drawings, sketches and symbols in addition to what they say and do. Let us first look at different types of drawings.

Block diagrams

- A very simple diagram
- Various items or pieces of equipment are represented by a box or rectangle
- Block diagrams show how things relate to each other
- See Fig. 1.10.

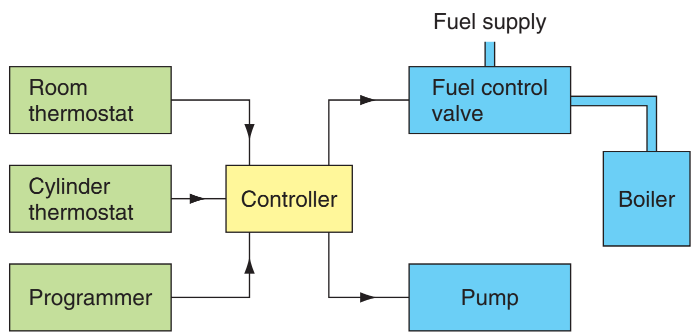


FIGURE 1.10
Space heating control system.

Circuit diagrams

- A circuit diagram shows most clearly how a circuit will work
- All the essential parts are represented by their graphical symbol
- The purpose of a circuit diagram is to help our understanding of the circuit
- It will be laid out without regard to the physical layout of the actual components
- See Fig. 1.11.

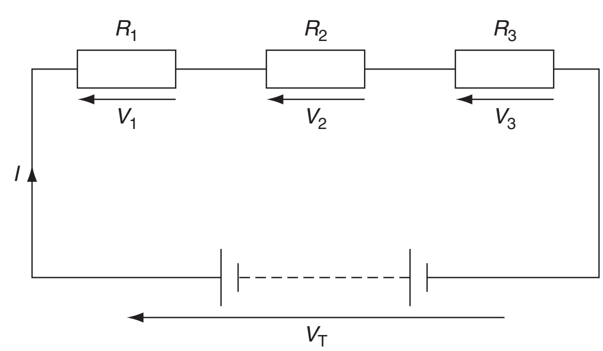


FIGURE 1.11
A series circuit.

Wiring diagram

- A wiring or connection diagram shows the detailed connections between components or items of equipment
- They do not indicate how a piece of equipment works
- The purpose of a wiring diagram is to help someone with the actual wiring and connection of the circuit
- See Fig. 1.12.

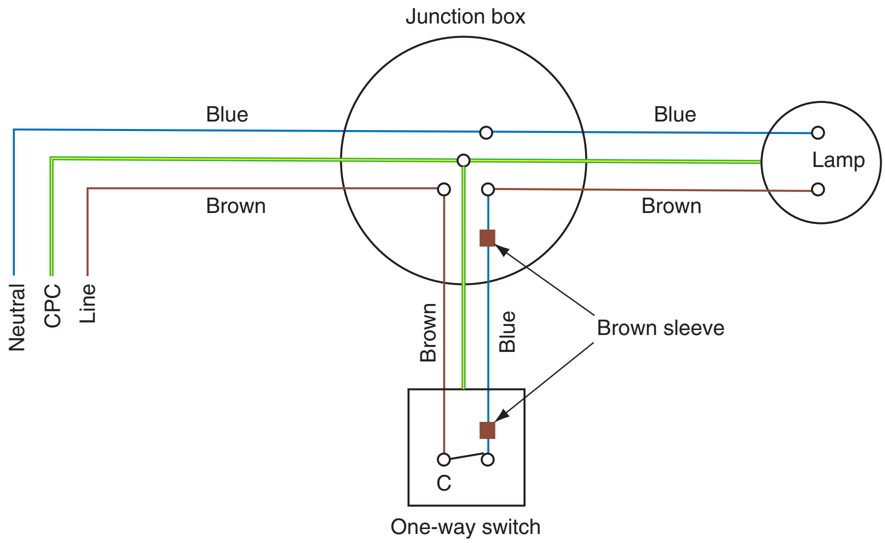


FIGURE 1.12
Wiring diagram of one-way switch control.

Location or layout diagrams or site plans

- These are scale drawings based upon the architects' site plan of the building
- They show the position of the electrical equipment to be installed
- All equipment is represented by its British Standard symbol
- A location or layout diagram is shown on the worksheet linked to this handout (Worksheet 12, Fig. 1.14).

Graphical symbols

- The standard symbols used by the electrotechnical industries are those recommended by British Standard EN 60617 *Graphical Symbols for Electrical Power, Telecommunications and Electronic Diagrams*
- Some of the more common electrical installation symbols and their meaning are shown in Fig. 1.13.

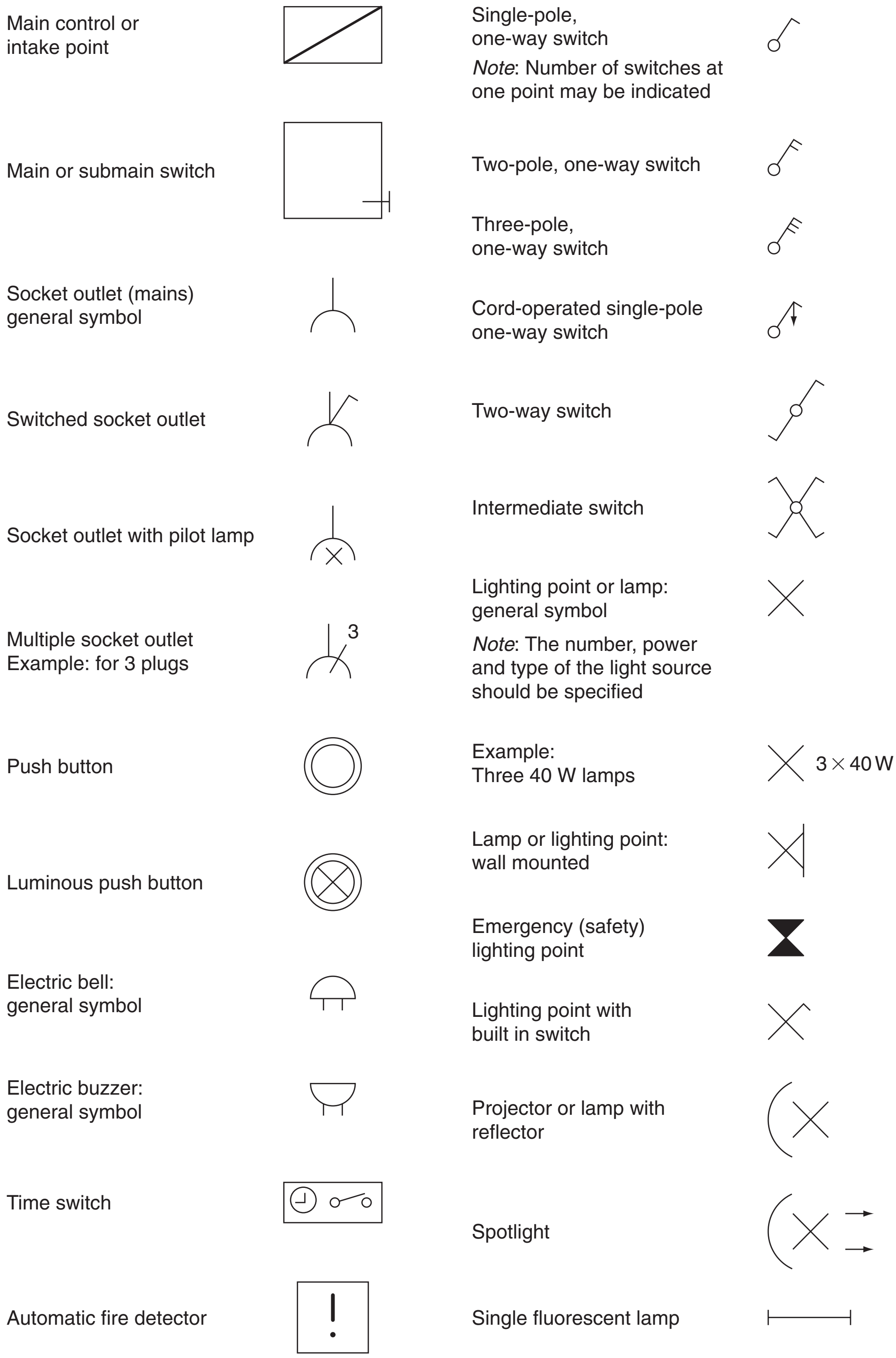


FIGURE 1.13
Some EN 60617 installation symbols.

Further information can be found on pages 65 to 70 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Technical information and communications in the electrotechnical industries

1. When you are working on site with your supervisor what types of technical information do you have available to help with the job in hand? Use the bullet points below to write in your answers.

- ....
- ....
- ....
- ....

2. A location or layout plan for a small domestic extension is shown in Fig. 1.14. Use the information given in Handout 15, Fig. 1.13, to identify the electrical equipment in each room on the worksheet overpage.

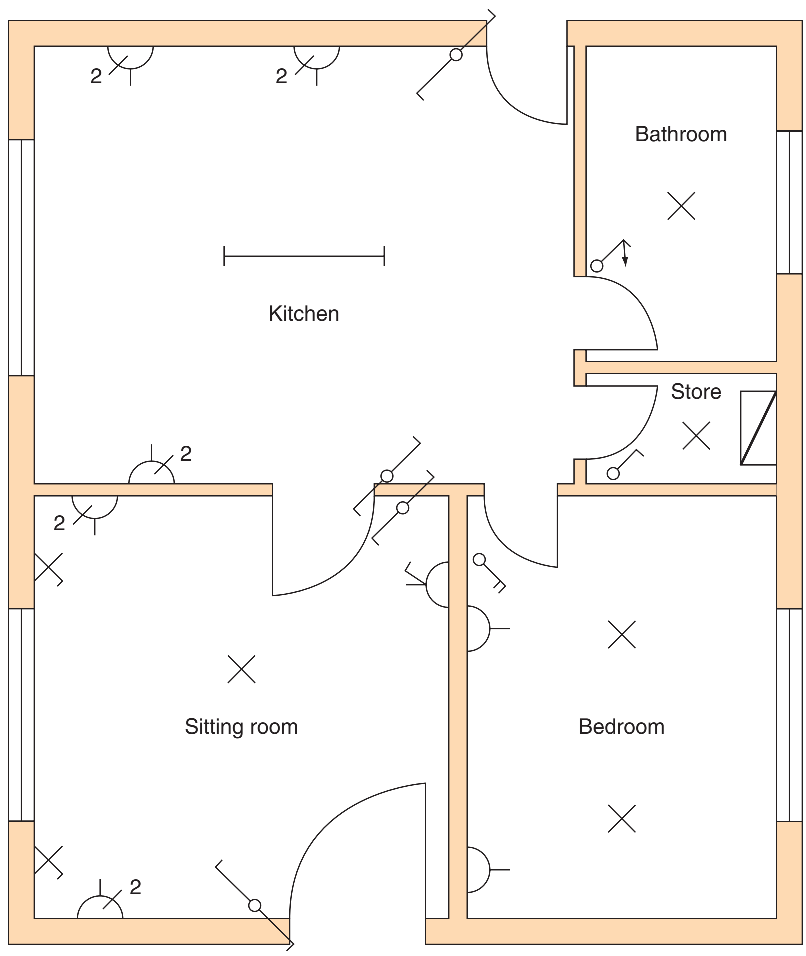


FIGURE 1.14
Layout drawing for electrical installation.

Store room ....

....

....

....

Bathroom ....

....

....

....

Kitchen ....

....

....

....

Sitting room ....

....

....

....

....

Bedroom ....

....

....

....

1. To prepare a Health and Safety Policy Statement is the responsibility of:
a. an employee ☐
b. an employer ☐
c. everyone ☐
d. the government. ☐

2. To provide all necessary PPE is the responsibility of:
a. an employee ☐
b. an employer ☐
c. everyone ☐
d. the government. ☐

3. The HSAWA puts the responsibility for safety at work upon:
a. an employee ☐
b. an employer ☐
c. everyone ☐
d. the government. ☐

4. To work safely and care for the safety of others is the responsibility of:
a. an employee ☐
b. an employer ☐
c. everyone ☐
d. the government. ☐

5. The IEE Wiring Regulations
a. are statutory regulations ☐
b. are non-statutory regulations ☐
c. are non-compulsory regulations ☐
d. apply only to new installations. ☐

6. Triangular yellow safety signs with a black border and symbol are called:
a. Advisory signs ☐
b. Mandatory signs ☐
c. Prohibition signs ☐
d. Warning signs. ☐

7. Square or rectangular green signs with a white symbol are called:
a. Advisory signs ☐
b. Mandatory signs ☐
c. Prohibition signs ☐
d. Warning signs. ☐

8. Circular blue signs with a white symbol are called:
a. Advisory signs ☐
b. Mandatory signs ☐
c. Prohibition signs ☐
d. Warning signs. ☐

9. Circular white signs with a red border and red cross bar are called:
- a. Advisory signs ☐
- b. Mandatory signs ☐
- c. Prohibition signs ☐
- d. Warning signs. ☐

10. A fire extinguisher showing a signal red flash on a red background contains:
- a. Carbon dioxide gas ☐
- b. Dry powder ☐
- c. Foam ☐
- d. Water. ☐

11. A fire extinguisher showing a black flash on a red background contains:
- a. Carbon dioxide gas ☐
- b. Dry powder ☐
- c. Foam ☐
- d. Water. ☐

12. A fire extinguisher showing a pale cream flash on a red background contains
- a. Carbon dioxide gas ☐
- b. Dry powder ☐
- c. Foam ☐
- d. Water. ☐

13. Lighting and power installations ensure that a building
- a. is safe to use in unforeseen or adverse conditions ☐
- b. is illuminated and heated to an appropriate level ☐
- c. ensures the efficiency of the installed systems ☐
- d. provides safe monitoring of industrial processes and systems. ☐

14. Instrumentation
- a. is safe to use in unforeseen or adverse conditions ☐
- b. is illuminated and heated to an appropriate level ☐
- c. ensures the efficiency of the installed systems ☐
- d. provides safe monitoring of industrial processes and systems. ☐

15. Electrical maintenance
- a. is safe to use in unforeseen circumstances ☐
- b. is illuminated and heated to an appropriate level ☐
- c. ensures the efficiency of the installed systems ☐
- d. provides safe monitoring of industrial processes and systems. ☐

16. Emergency lighting and security systems ensure that a building
- a. is safe to use in unforeseen circumstances ☐
- b. is illuminated and heated to an appropriate level ☐
- c. ensures the efficiency of the installed systems ☐
- d. provides safe monitoring of industrial processes and systems. ☐

17. The Contracts Manager of a company will

a. oversee a number of electrical contracts ☐
b. be responsible for the day-to-day management of one specific contract ☐
c. be the leader of a small team installing electrical systems ☐
d. be an operative who has a basic skill and qualification in mechanical rather than electrical engineering. ☐

18. A mechanical/fitter will

a. oversee a number of electrical contracts ☐
b. be responsible for the day-to-day management of one specific contract ☐
c. be the leader of a small team installing electrical systems ☐
d. be an operative who has a basic skill and qualification in mechanical rather than electrical engineering. ☐

19. The Project Manager of a company will

a. oversee a number of electrical contracts ☐
b. be responsible for the day-to-day management of one specific contract ☐
c. be the leader of a small team installing electrical systems ☐
d. be an operative who has a basic skill and qualification in mechanical rather than electrical engineering. ☐

20. The Supervisor/Foreman will

a. oversee a number of electrical contracts ☐
b. be responsible for the day-to-day management of one specific contract ☐
c. be the leader of a small team installing electrical systems ☐
d. be an operative who has a basic skill and qualification in mechanical rather than electrical engineering. ☐

21. Amicus is

a. the electrical industry's safety regulatory body ☐
b. a professional body supporting electrotechnical organizations ☐
c. the British Standard for electrical power supplies ☐
d. the Trade Union representing electrical employees. ☐

22. The ECA is

a. the electrical industry's safety regulatory body ☐
b. a professional body supporting electrotechnical organizations ☐
c. the British Standard for electrical power supplies ☐
d. the Trade Union representing electrical employees. ☐

23. The NICEIC is

a. the electrical industry's safety regulatory body ☐
b. a professional body supporting electrotechnical organizations ☐
c. the British Standard for electrical power supplies ☐
d. the Trade Union representing electrical employees. ☐

24. A scale drawing showing the position of equipment by graphical symbols is a description of a

a. block diagram ☐
b. layout diagram ☐
c. wiring diagram ☐
d. circuit diagram. ☐

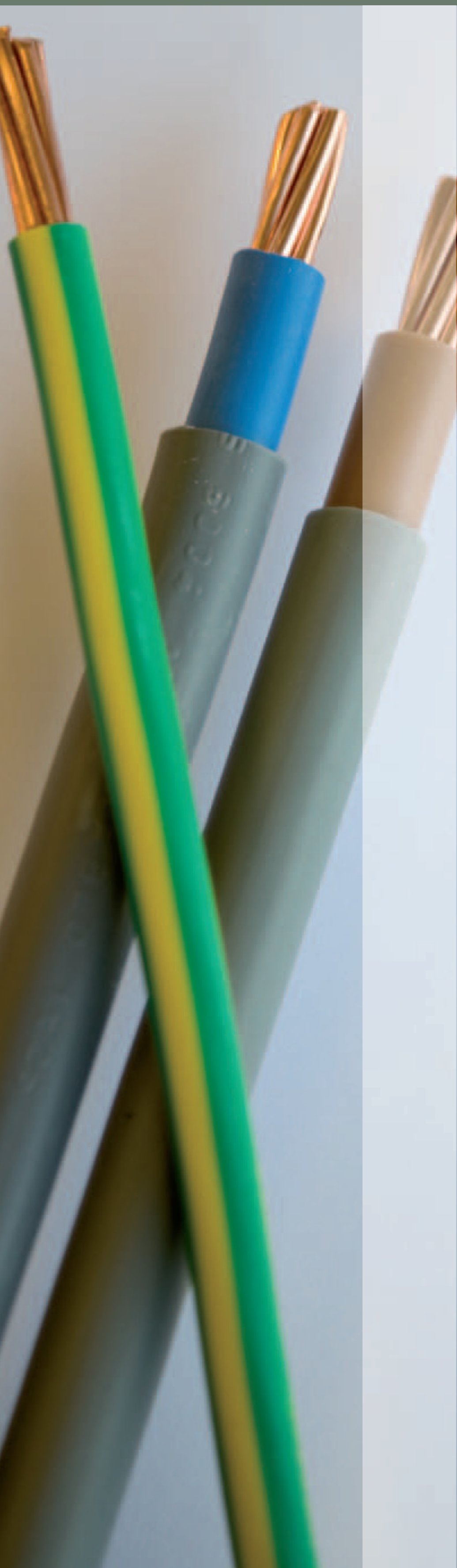
25. A diagram which shows the detailed connections between individual items of equipment is a description of a

a. block diagram ☐
b. layout diagram ☐
c. wiring diagram ☐
d. circuit diagram. ☐

26. A diagram which shows most clearly how a circuit works, with all items represented by graphical symbols is a description of a

a. block diagram ☐
b. layout diagram ☐
c. wiring diagram ☐
d. circuit diagram. ☐

Answers to Worksheets 1 to 13



Worksheet 1

EMPLOYERS' RESPONSIBILITIES

Maintain equipment – fit machine guards – install fume extractors – provide PPE – provide safety training – put up safety signs – prepare a Health and Safety Policy Statement – provide adequate welfare facilities – provide first aid facilities – provide fire fighting equipment – provide means of escape from fire – report certain injuries, diseases and dangerous occurrences.

EMPLOYEES' RESPONSIBILITIES

Care for other workers – wear PPE – attend safety training courses – co-operate with your employer – do not damage safety equipment – do not misuse safety equipment – wear a hard hat in a hard hat area – see a first aider with minor cuts and injuries – complete an accident/first aid report following minor injuries.

Worksheet 2

Statutory Regulations are **all those given except IEE Regs**

Non-Statutory Regulations are **IEE Regs No 4 only**

Worksheet 3

1 = G, 2 = M, 3 = B, 4 = L, 5 = F, 6 = N, 7 = A, 8 = E,
9 = P, 10 = H, 11 = K, 12 = O, 13 = C, 14 = D, 15 = I, 16 = J

Worksheet 4

Eyes – spectacles – goggles – face screens.

Head and neck – helmets – bump caps – hairnets – sou'westers – cape hoods.

Ears – earplugs – ear muffs.

Hands and arms – gloves – gauntlets – mitts – wrist cuffs – armlets.

Feet and legs – Safety boots, shoes, trainers – gaiters – leggings – spats and clogs.

Lungs – disposable respirator – half masks – full face respirator with filtering cartridge – powered respirator blowing filtered air to a mask – fresh air hose equipment – breathing apparatus (self-contained and fresh air line types).

Whole body – conventional or disposable overalls – boiler suits – warehouse coats – donkey jackets – high visibility clothing – chemical suits – thermal clothing – safety harness.

Worksheet 5

1. The eight actions given in Handout 7.
2. 2.1. seek appropriate treatment – 2.2. report the accident to a supervisor – 2.3. record details in first aid/accident book.
3. The company vehicle – the site cabin – any appropriate answer.
4. Make the hazard safe if possible and then report to your supervisor.

Worksheet 6

Water – Signal red flash on red – paper, wood and fabric fires.

Dry powder – French blue flash on red – any type of fires.

Foam – Pale cream flash on red – paper, wood, fabric, flammable liquids.

Vapourizing foam – Emerald green flash on red – any type of fires.

Carbon Dioxide gas – Black flash on red – flammable liquids, flammable gases and electrical fires.

Worksheet 7

1. Switch off power if possible – remove person without touching – dial 999 for professional help – apply resuscitation and cardiac massage.
2. I think we are looking to say here that it is very easy to get an electric shock. Little ones you might get away with but in order to avoid the big one you must apply safe working practice, including isolation.
3. Any acceptable sketch or description is OK – Fig. 1.9 gives one example.

Worksheet 8

See Handout 10.

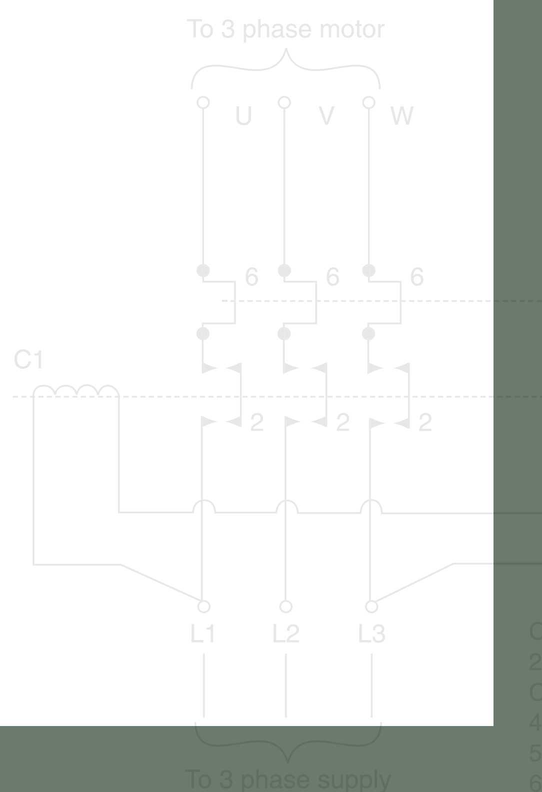
Worksheet 9

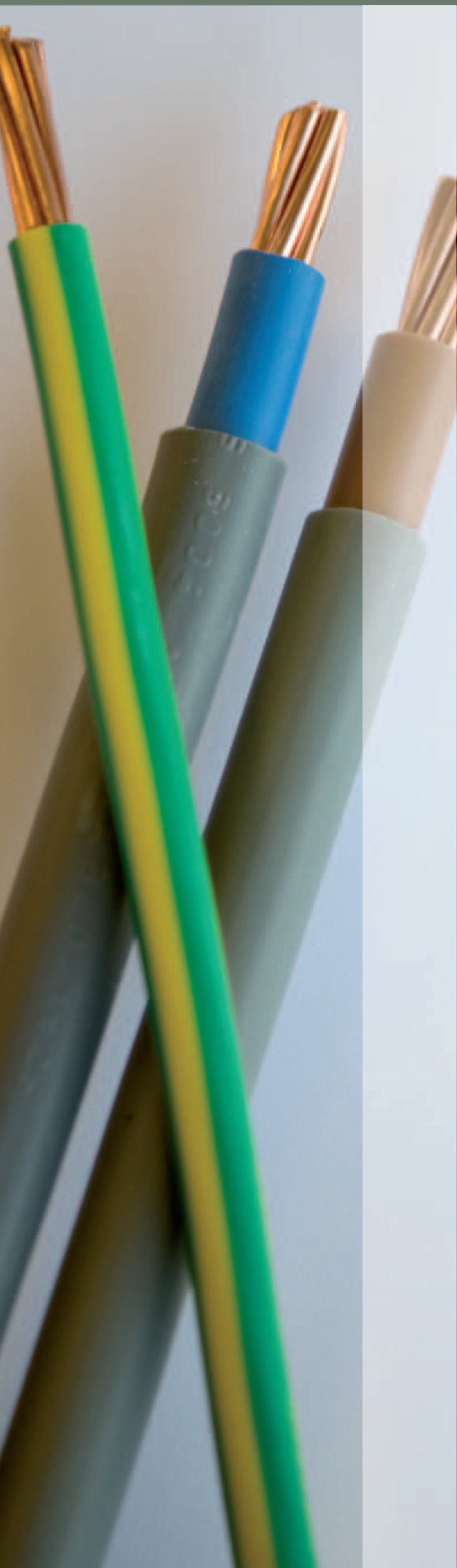
Any acceptable answers at lecturer's discretion. Answers may provide group discussion material.

Worksheet 10

Part A. Answers at lecturer's discretion. Answers may identify the lack of a clear distinction in the roles and responsibilities of people with the same job title.

Part B. Definitions may be found in Part 2 of the IEE Regulations and page 53 of *Basic Electrical Installation Work* 5th Edition.





Worksheet 11

1. Answers at lecturer's discretion – for example ECA – NICEIC.
2. Shows respectability – gives access to technical information and support – some work only available to members – display respected logo on vehicles – advertise on specialist contractors' lists.
3. Amicus.
4. Answers at lecturer's discretion – see Handout 13.

Worksheet 12

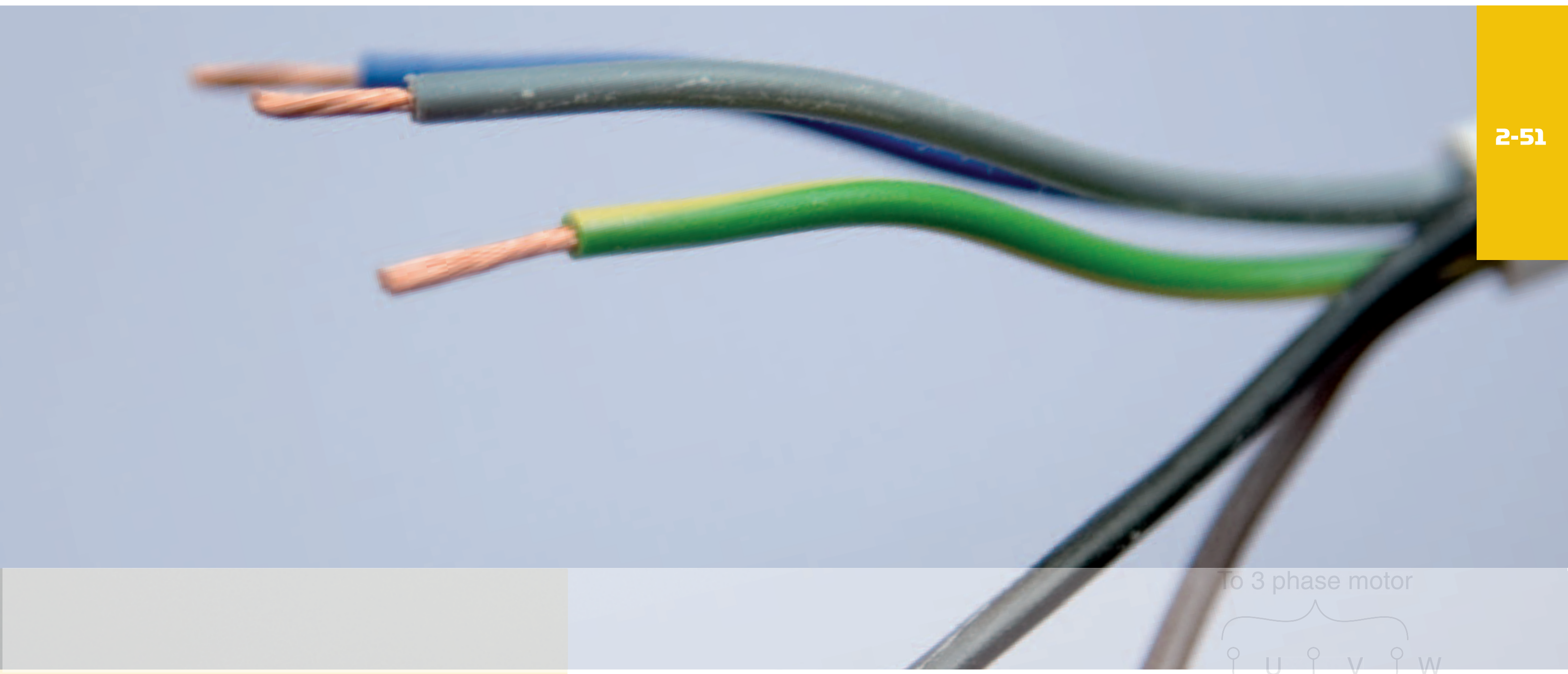
1. Answers at lecturer's discretion but I would imagine at least a site plan.
2. **Store room,** mains intake + light + switch – **Bathroom,** cord operated switch + light – **Kitchen,** 2–2 way switches + fluorescent + 3 double sockets (they are shown **not switched,** but these days one would expect them **to be switched),** how would they change the symbol to show them switched? – **Sitting room,** 2–2 way switches + light + 2 switched wall lights + 2 double sockets + 1 switched socket – **Bedroom,** 1–2 gang switch + 2 lights + 2 single sockets.

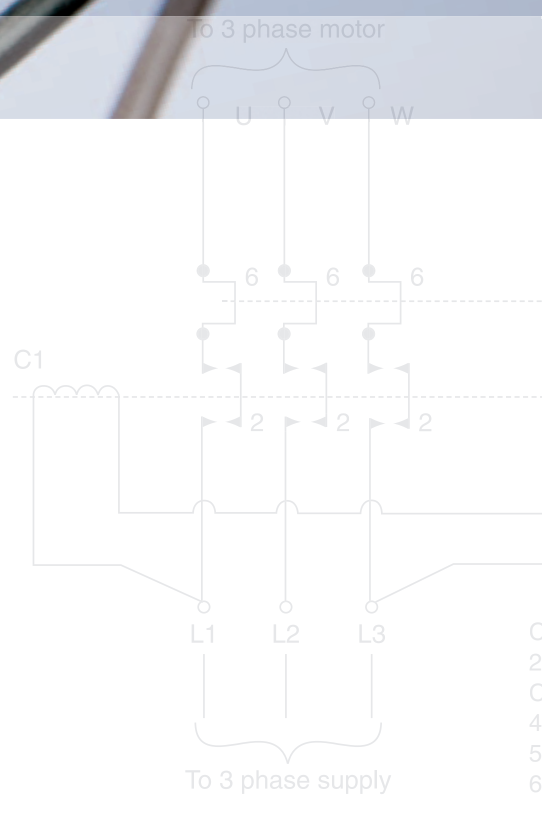
Worksheet 13 (MC questions)

1 = b	**10 = d**	**19 = b**
2 = b	**11 = a**	**20 = c**
3 = c	**12 = c**	**21 = d**
4 = a	**13 = b**	**22 = b**
5 = b	**14 = d**	**23 = a**
6 = d	**15 = c**	**24 = b**
7 = a	**16 = a**	**25 = c**
8 = b	**17 = a**	**26 = d**
9 = c	**18 = d**	

2

Core Unit 2, Level 2 Principles of Electrotechnology (Stage 1)





Level 2 – Certificate in Electrotechnical Technology

Contents

Basic units used in electrotechnology

- In all branches of science and engineering there is a need for a practical system of units which everyone can use.
- In 1960 the SI system was brought into international use (Table 2.1).

Table 2.1 SI Units

SI unit	Measure of	Symbol
The fundamental units		
Metre	Length	m
Kilogram	Mass	kg
Second	Time	s
Ampere	Electric current	A
Kelvin	Thermodynamic temperature	K
Candela	Luminous intensity	cd
Some derived units		
Coulomb	Charge	C
Joule	Energy	J
Newton	Force	N
Ohm	Resistance	Ω
Volt	Potential difference	V
Watt	Power	W

- Like all metric systems, SI units may be increased or reduced by using multiples or sub-multiples of 10. Some of the more common prefixes and their symbols are shown in Table 2.2.

Table 2.2 Prefixes for use with SI Units

Prefix	Symbol	Multiplication factor		
Mega	M	$\times 10^{6}$	or	$\times$ 1,000,000
Kilo	k	$\times 10^{3}$	or	$\times$ 1000
Hecto	h	$\times 10^{2}$	or	$\times$ 100
Deca	da	$\times 10$	or	$\times$ 10
Deci	d	$\times 10^{-1}$	or	$\div$ 10
Centi	c	$\times 10^{-2}$	or	$\div$ 100
Midi	m	$\times 10^{-3}$	or	$\div$ 1000
Micro	μ	$\times 10^{-4}$	or	$\div$ 1,000,000

Further information can be found on pages 80 to 81 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Basic SI Units

Quantity	Measure of	Basic Unit	Symbol	Notes
area	length × length	metre squared	m^2	
current I	electric current	ampere	A	
energy	ability to do work	Joule	J	Joule is a very small unit 3.6×10^6 J = 1 kWh
force	the effect on a body	Newton	N	
frequency	number of cycles	Hertz	Hz	Mains frequency is 50 Hz
length	distance	metre	m	
mass	amount of material	kilogram	kg	1 metric tonne = 1000 kg
magnetic flux Φ	magnetic energy	Weber	Wb	
magnetic flux density B	number of lines of magnetic flux	Tesla	T	
potential or pressure	voltage	volt	V	
period T	time taken to complete one cycle	second	s	The 50 Hz mains supply has a period of 20 ms
power	rate of doing work	Watt	W	
resistance	opposition to current flow	Ohm	Ω	
resistivity	resistance of a sample piece of material	Ohm metre	ρ	Resistivity of copper is 17.5×10^{-9} Ωm
temperature	hotness or coldness	Kelvin	K	0°C = 273 K. A change of 1 K is the same as 1°C
time	time	second	s	60 s = 1 min 60 min = 1 h
weight	force exerted by a mass	kilogram	kg	1000 kg = 1 tonne

A more detailed description can be found in Chapter 4 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Force, mass and movement

- The presence of a force can only be detected by its effect on an object.
- A force may cause a stationary object to move, for example a car and engine.
- A force may cause a moving object to stop, for example brake linings on wheel discs.
- Gravity causes objects to fall to the ground.
- The accepted rate of acceleration due to gravity is $9.81\,\text{m/s}^2$.

Now Force (N) = mass (kg) × Acceleration (m/s^2)

Further information can be found on pages 84 to 89 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

The simple alternator

If a loop of wire is rotated between the poles of a magnet as shown in Fig. 2.1, the loop of wire will cut the lines of magnetic flux which pass from the north to the south pole. This flux cutting causes a voltage to be induced in the loop of wire.

If this induced voltage is collected by carbon brushes at the slip rings and displayed on a meter or CRO, it will be seen to induce first a positive and then a negative voltage. We call this changing voltage, an alternating voltage and the shape that it follows is called, in mathematics, sinusoidal.

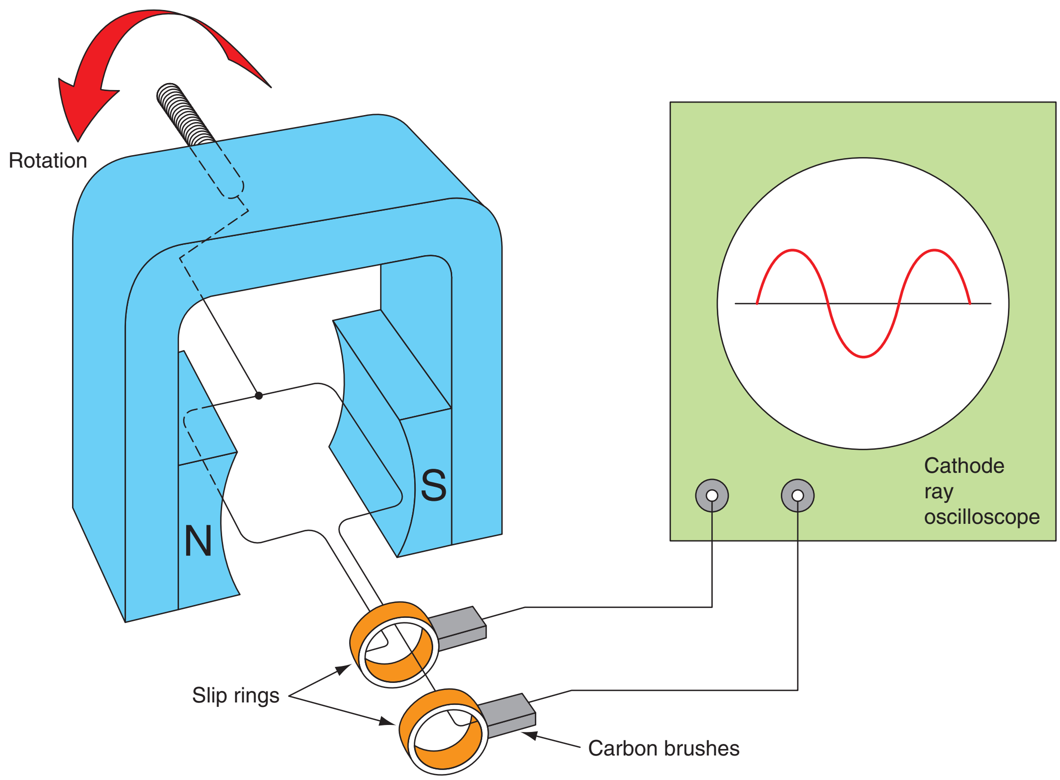


FIGURE 2.1
Simple a.c. generator or alternator.

The efficiency of any machine is a measure of its output to its input energy or power expressed as a percentage. So,

$$\textbf{Efficiency} = \eta = \frac{\textbf{Output}}{\textbf{Input}} \times \frac{\textbf{100}}{\textbf{1}}$$

Mechanics and machines

1. Using the bullet points, very briefly describe what we mean by mass and weight.

   Mass .... Weight ....

   ....

2. Calculate the gravitational force being exerted on a pallet containing bags of cement having a total mass of 100 kg. Show the formulae

   Force = ...

3. Identify the SI unit symbol and multiples of the following quantities:

   (a) Electric current–base unit .... Symbol ....

   Give two common sub-multiples used in electronics: 1. .... 2. ....

   (b) Power–base unit .... Symbol ....

   Give two common multiples used in power engineering: 1 .... 2 ....

   (c) Temperature–base unit .... Symbol ....

   Freezing point is equal to .... on the Kelvin scale.

   Boiling point is equal to .... on the Centigrade scale.

   A comfortable room temperature is ....on the Centigrade scale.

4. Calculate the resistivity of 100 m of 2.5 mm copper cable using the values given in Handout 2.

   Show the formulae ....

5. Describe with bullet points and a simple sketch how a voltage is generated by a simple alternator, for example, magnetic fields and movement.

6. Calculate the efficiency of a simple machine which has an output of 1000 W when taking 1200 W from the supply.

7. A machine is known to be 70% efficient and takes 1000 W from the mains supply. Calculate the output of the machine and show all formulae and calculations.

Conductors and insulators

- All matter is made up of atoms.

- All atoms are made up of a central positively charged nucleus surrounded by negatively charged electrons.

- The electrical properties of materials depend largely upon how tightly the electrons are bound to the nucleus.

- **A Conductor** is a material in which the electrons are loosely bound to the central nucleus and, in fact, can very easily become free electrons.

- Good conductors are gold, silver, copper, aluminium, brass, etc.

- **An insulator** is a material in which the electrons are very tightly or strongly bound to the central nucleus.

- Good insulators are PVC, rubber, perspex, glass, wood, porcelain, etc.

Further information can be found on page 81 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Electron flow or electric current

- If a battery is attached to a "good conductor" material, the free electrons drift toward the positive terminal, as shown in Fig. 2.2.

- This drift of electrons within a conductor is what we know as an electric current flow.

- Current flow is measured in amperes and given the symbol *I*.

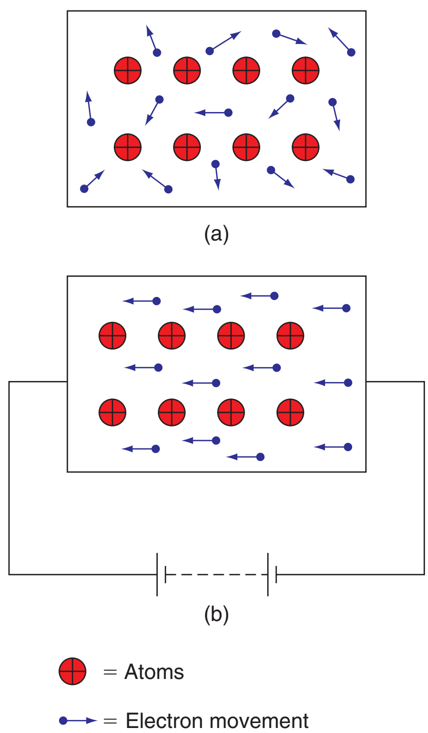


FIGURE 2.2
Atoms and electrons in a material: (a) shows the random movement of free electrons and (b) shows the free electrons drifting toward the positive terminal.

Further information can be found on page 81 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Three effects of an electric current

When an electric current flows in a circuit it can have one or more of the following three effects, *heating, magnetic or chemical.*

Heating effect

- The electrons moving in the conductor causes the conductor to heat up.

- The amount of heat generated depends upon the:

  1. amount of current flowing

  2. dimensions of the conductors

  3. type of conductor material used.

- Practical applications of the heating effect are:

  1. radiant heaters

  2. circuit protection, fuses and MCBs.

Magnetic effect

- Whenever a current flows in a conductor a magnetic field is set up around the conductor like an extension of the insulation.
- Increasing the current increases the magnetic field.
- Switching the current off causes the magnetic field to collapse.
- Practical applications of the magnetic effect are:

  1. electric motors and generators
  2. door chimes.

Chemical effect

- When an electric current flows through a conducting liquid, the liquid separates into its chemical parts – a process called electrolysis.
- Alternatively, if two metals are placed in a conducting liquid they react chemically and produce a voltage.
- Practical applications of the chemical effect are:
  1. industrial processes such as electroplating
  2. motor car batteries.

Further information can be found on pages 11 and 12 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Conductors, insulators and electrical effects

1. List **four** different materials used as conductors and give **one** application for each. The most obvious at 1.1 below has been filled in for you.

   1.1. *Copper – used for electrical cables*

   1.2. ....

   1.3. ....

   1.4. ....

2. List **four** different materials used as insulators and give **one** application for each.

   2.1. ....

   2.2. ....

   2.3. ....

   2.4. ....

3. Explain very briefly how the atomic structure of an insulator varies from the atomic structure of a conductor. Use a sketch if that is helpful.

4. In simple terms describe the reaction of electrons when charged and the concept of an electric current. You might like to use a sketch.

5. State the **three** effects of an electric current and give **three** practical applications from your own experience at work.

The three effects	*Practical applications*
1.	1. ....
	2. ....
	3. ....
2.	1. ....
	2. ....
	3. ....
3.	1. ....
	2. ....
	3. ....

Further information can be found on pages 81 and 111 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

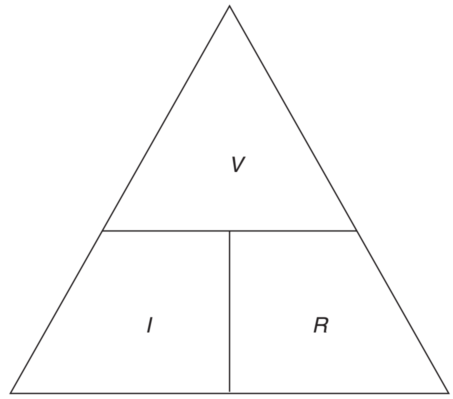
Ohm's law

In 1826 Dr George Ohm published the results of an experiment he had carried out to discover the relationship between current voltage and resistance of an electric circuit.

He found that Voltage = Current × Resistance

Current = Voltage ÷ Resistance

and Resistance = Voltage ÷ Current



Series circuits

In any series circuit a current *I* will flow through all parts of the circuit as a result of the potential difference supplied by the battery and shown in Fig. 2.3.

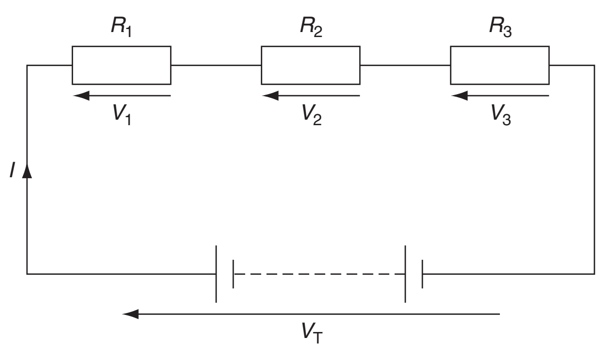


FIGURE 2.3
A series circuit.

- In a series circuit the current is the same throughout the circuit.
- When the current flows through each resistor in the circuit there will be a voltage drop across that resistor as shown in Fig. 2.3.
- This is because of Ohm's law, $V = I \times R$ volts.
- The total voltage V_T is given by $V_T = V_1 + V_2 + V_3$ volts.
- The total resistance R_T is given by $R_T = R_1 + R_2 + R_3$ ohms.

Further information can be found on page 103 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Parallel resistors

- In any parallel circuit the same voltage acts across all parts of the circuit as shown in Fig. 2.4.

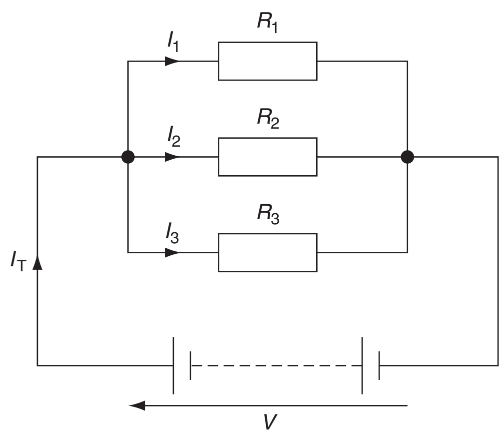


FIGURE 2.4
A parallel circuit.

- In a parallel circuit the voltage is the same throughout the circuit.
- The total current is made up of the sum (the addition) of the individual currents as shown in Fig. 2.4.
- Therefore $I_T = I_1 + I_2 + I_3$
- The total resistance R_T found from $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Example: If $R_1 = 2\,\Omega$ $R_2 = 3\,\Omega$ and $R_3 = 4\,\Omega$

For series circuits Total $R = R_1 + R_2 + R_3$

Total $R = 2 + 3 + 4 = 9\Omega$

For parallel circuits

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_T} = \frac{1}{2} + \frac{1}{3} + \frac{1}{4}$$

$$\frac{1}{R_T} = \frac{6+4+3}{12} = \frac{13}{12}$$

$$\therefore R_T = \frac{12}{13} = 0.92\,\Omega$$

Further information can be found on pages 104 and 105 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Series and parallel resistors

1. Resistors of 6 Ω and 12 Ω are connected first in series and then in parallel to a 12V battery. In the space below, sketch the circuit and calculate the total resistance and total current flowing for each connection.

Series circuit

Parallel circuit

2. Show below how an ammeter and voltmeter would be connected to the same circuit, to measure the quantity of all currents and voltages described in 1 overpage.

Series	*Parallel*

3. Resistors of 5 Ω, 10 Ω and 20 Ω are connected first in series and then in parallel to a 35 V power supply. In the space below sketch the circuit and calculate the total resistance and total current flowing for each connection.

Series	*Parallel*

Magnetic fields and flux patterns

Lines of magnetic flux have no physical existence but were introduced by Michael Faraday as a way of explaining the magnetic energy existing in space or in a material. The magnetic fields around a permanent magnet, a current carrying conductor and a solenoid are shown in Figs 2.5, 2.6 and 2.7.

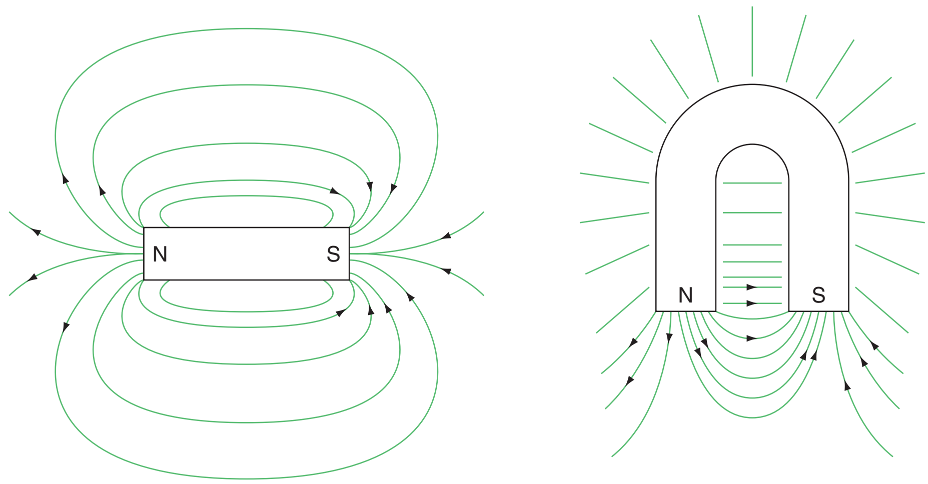


FIGURE 2.5
Magnetic fields around a permanent magnet.

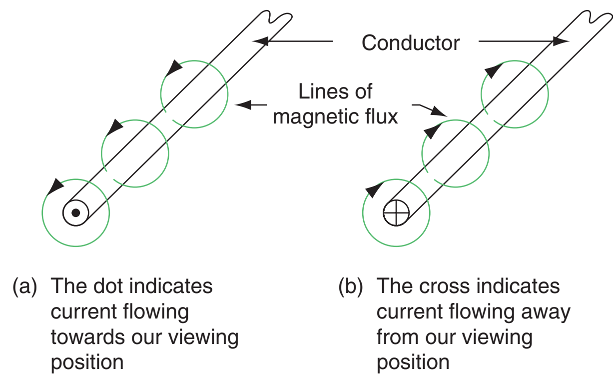


FIGURE 2.6
Magnetic fields around a current carrying conductor.

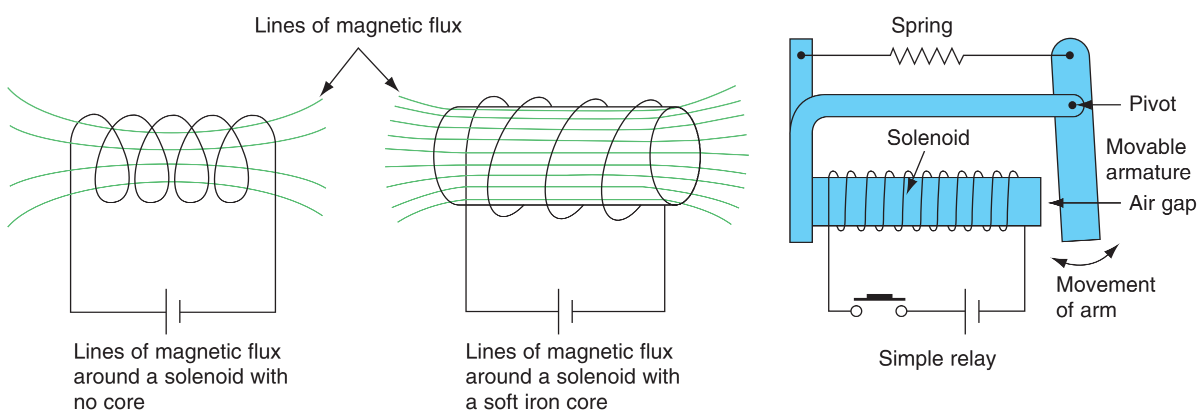
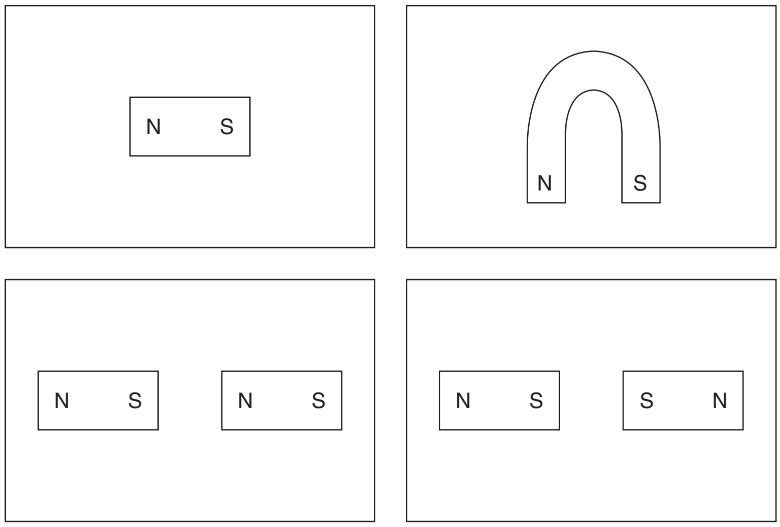


FIGURE 2.7
The solenoid and one practical application: the relay.

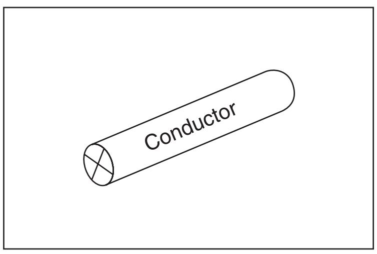
Further information can be found on pages 112 and 115 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Magnetism

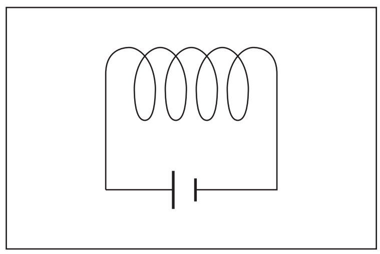
1. Draw in the magnetic flux patterns for the magnets shown below:



2. Sketch below the magnetic fields around a current carrying conductor



3. Sketch below the magnetic field around a solenoid



4. Complete the following statements:

Like poles ....

....

....

Unlike poles ....

....

....

Electrical transformers

- A transformer is an electrical machine without moving parts, which is used to change the value of an alternating voltage.
- A transformer will only work on an alternating supply.
- It will not normally work from a d.c. supply such as a battery.
- A transformer such as that shown below in Fig. 2.8 consists of two coils called the primary and secondary coils or windings, wound on to a common iron core.
- An alternating voltage applied to the primary winding establishes an alternating magnetic flux in the core.
- The magnetic flux in the core causes a voltage to be induced in the secondary winding of the transformer.
- The voltage in both the primary and secondary windings is proportional to the number of turns.

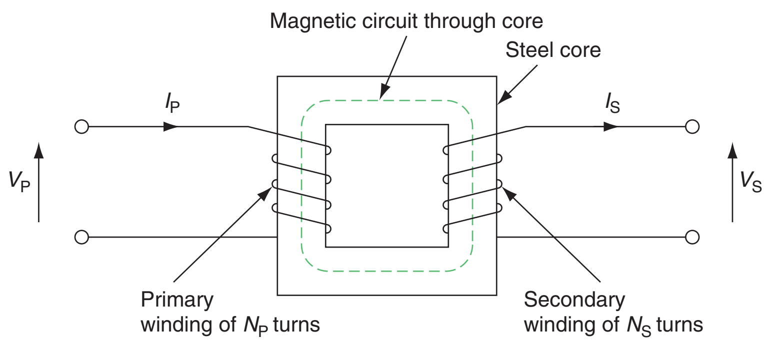


FIGURE 2.8
A simple transformer.

- Because it has no moving parts, a transformer can have a very high efficiency.
- Large power transformers, used on electrical distribution systems, can have an efficiency of better than 90%.
- These power transformers need cooling to take the heat generated away from the core. This is often achieved by totally immersing the core and windings in insulating oil. A sketch of a power transformer can be seen in Fig. 5.18 (page 116) of *Basic Electrical Installation Work*.
- Very small transformers are used in electronic applications.
- Small transformers are used as isolating transformers in shaver sockets.
- Small transformers can also be used to supply SELV sources.

Electrical power on the National Grid

- Electricity is generated in large modern power stations at 25 kV.
- It is then transformed up to 132 or 270 kV for transmission to other parts of the country on the National Grid network.
- Raising the voltage to these very high values reduces the losses.
- 66 or 33 kV is used for secondary transmission lines.
- These high voltages are reduced to 11 kV at local sub-stations for distribution to end users such as factories, shops and houses at 400 and 230V.
- The ease and efficiency of changing the voltage levels is only possible because we generate an a.c. supply. Transformers are then used to change the voltage levels to that which is appropriate. Very high voltages are for transmission, lower voltages are for safe end use. This would not be possible if a d.c. supply was generated.
- Fig. 2.9 below shows a simplified diagram of electricity distribution.

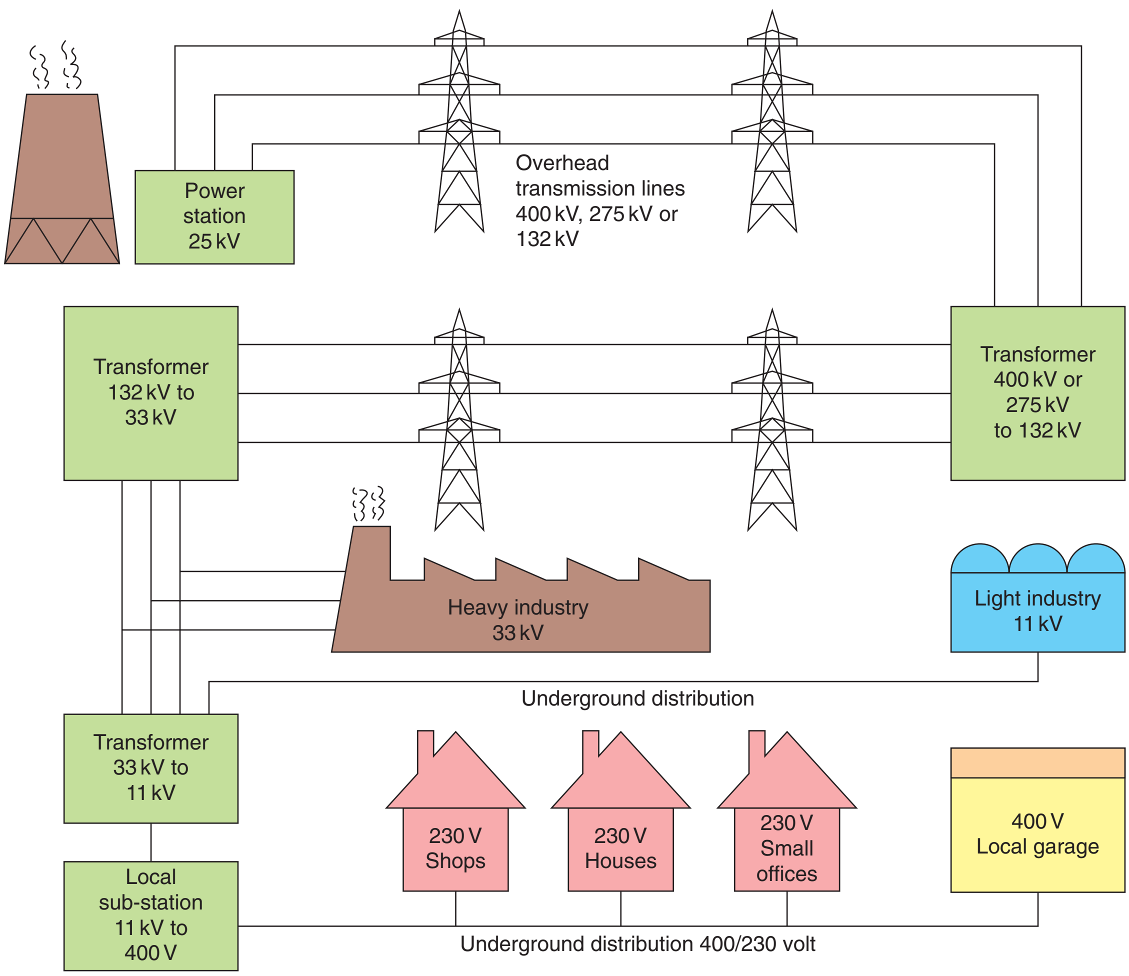


FIGURE 2.9
Simplified diagram of the distribution of electricity from power station to consumer.

Further information can be found on page 117 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Transformers and electrical transmission

1. In the space below sketch the construction of a simple transformer. Label the primary and secondary windings and describe what is laminated and why.

2. State the benefits of using an a.c. supply compared with a d.c. supply.

....

....

....

....

....

....

3. Draw a sketch below to show how electricity is generated, transmitted on overhead lines to an outdoor sub-station, before being fed to a factory, local shops and houses. Show how your college supply is connected to this arrangement. Show the voltage levels at each stage. My college receives an 11 kV supply with an 11 kV ring distribution around the major buildings.

Electrical circuits

Refer to Fig. 2.10 for a TN-S system of supply.

An electrical circuit has the following *five* components:

1. The *source* of electrical energy is the secondary winding of the supply authority's sub-station. This will be an a.c. supply.
2. The *circuit protection* which might be a fuse or MCB to protect against overcurrent.
3. The *circuit conductors or cables* to carry power to the load.
4. The *means of controlling* the circuit.
5. *The load*, this is a piece of equipment which requires electricity to make it work.
   - From the consumer's unit *circuit conductors or cables* will carry electrical energy to the power and lighting circuits of the installation.
   - Dishwashers, toasters, vacuum cleaners, lighting and electronic equipment put the electrical energy to good use, and they are collectively called the *load*.
   - *Circuit control* for electrical equipment is produced by switches, thermostats, dimmers and contactors.

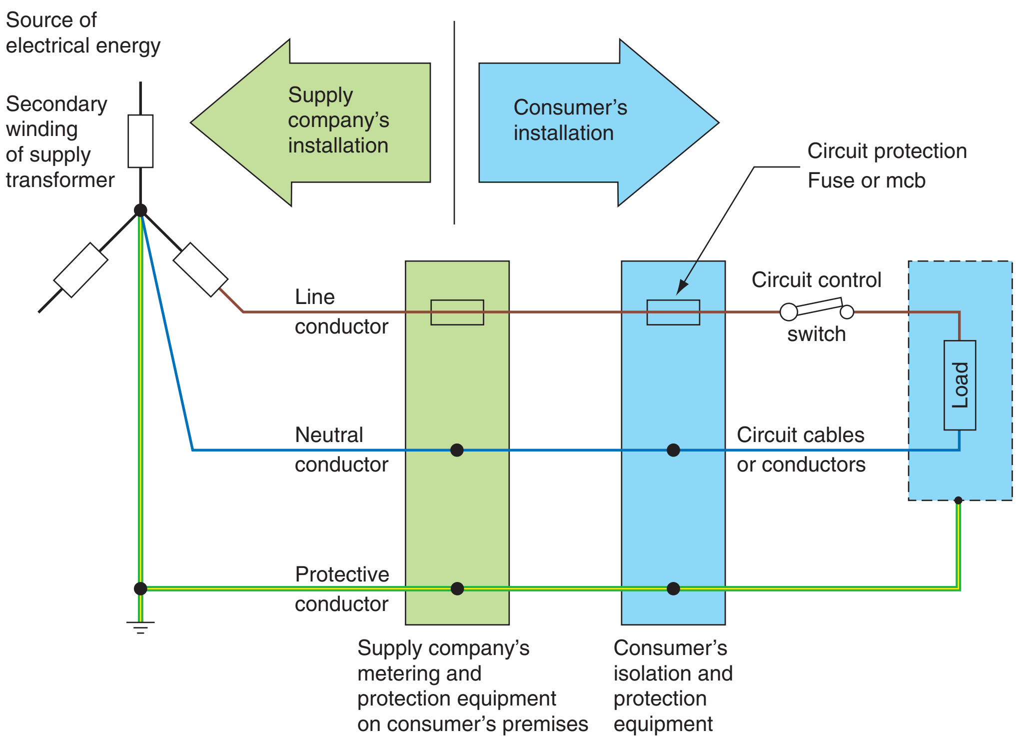


FIGURE 2.10
Component parts of an electric circuit.

Further information can be found on pages 128 to 129 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Electrical circuits

1. In the space below sketch a simple electrical circuit or block diagram and label the component parts showing:

    (a) the source of supply

    (b) the circuit conductors

    (c) the circuit protection

    (d) the circuit control

    (e) the load

2. In the space below sketch an electrical cable. Show the component parts of the cable, particularly *the conductor, the insulation and the sheathing* (you might like to look at Fig. 6.1 and Fig. 6.2 of *Basic Electrical Installation work* 5th Edition).

State two common materials used for cable conductors:

1 ....

2 ....

State two common materials used for cable insulation:

1 ....

2 ....

3. In 2004 new (harmonized with Europe) fixed wiring cable colours were introduced. We are now using the new cable colours for all our new electrical installation work, but for many years to come, you will work on electrical installations wired in the "old colours". Identify the old and new fixed wiring colours.

Single phase supplies

Old line colour ....

Old neutral colour ....

New line colour ....

New neutral colour ....

CPC colour for both old and new is ....

Three phase supplies

Old line colours **L**$_1$ .... **L**$_2$ .... **L**$_3$ ....

Old neutral colour **N** ....

New line colours **L**$_1$ .... **L**$_2$ .... **L**$_3$ ....

New neutral colour N ....

CPC Colour for both old and new is ....

Earthing and bonding

- Installing electrical systems which will be safe for those who will use them is absolutely fundamental to the safe use of electricity.

- Electrical systems installed in accordance with the IEE Regulations (BS 7671) will be safe for those who will use them.

- Chapter 13 of the IEE Regulations deals with the fundamental principles for safety and tells us that the application of the method of protective equipotential bonding to earth is one of the important principles for safety (IEE Regulation 131.2.2).

- When we say connected to *earth* we mean the general conductive mass of the planet Earth, whose potential is taken as zero.

- *Earthing* is the act of connecting the *exposed conductive parts* of an installation to the main protective earthing terminal of the installation.

- *Exposed conductive parts* are the metal parts of the installation which are not *normally live*, but which may become live under fault conditions. For example, the metalwork of an electrical appliance or the trunking and conduits of the installation.

- All other metalwork within a building is called *extraneous conductive parts* and this includes structural steelwork and other service pipes such as gas, water, radiators and sinks.

- The extraneous conductive parts are prevented from becoming live by *bonding* them together and connecting them to the main protective earthing terminal of the installation.

- The bonding process maintains an *equipotential* (of zero volts) between all exposed and extraneous conductive parts.

Electric shock protection

- An electric shock occurs when a person becomes a part of the electrical circuit. Fig. 1.9 in Unit 1 shows how this might happen.

- The intensity of the electric shock will depend upon many factors such as age, fitness and the circumstances in which the shock is received.

- In general terms, a shock current of more than 50 mA can be fatal.

- Electric shock may occur in two ways, through direct contact or indirect contact.

- *Direct contact* means actually touching live parts. People are protected from touching live parts by *Basic Protection*. In this case protection is provided by:
  - insulating live parts
  - placing barriers or enclosures around live parts
  - placing obstacles in front of live parts
  - placing live parts out of reach
  - in accordance with Section 416 of the IEE Regulations.

- *Indirect contact* means touching conductive parts such as the metalwork of an appliance which has become live as a result of a fault. The potential voltage on this metalwork rises above earth potential and an electric shock may occur when someone touches the metalwork. *Fault Protection* gives protection against electric shock caused by indirect contact (IEE Regulation 131.2.2).

- Methods of fault protection are described in IEE Regulations 411.3 to 6.

- The most universally used method of Fault Protection for supplies in the United Kingdom is protective equipotential bonding coupled with automatic disconnection of the supply by fuse or circuit breaker.

Protective equipotential bonding coupled with automatic disconnection of the supply

- Protective equipotential bonding was discussed at the beginning of this handout under the heading Earthing and bonding.

- Automatic disconnection of the supply is achieved by fuses MCBs and RCDs (residual current devices).

- If the circuit shown in Fig. 2.10 in Handout 13 was operating normally, current would flow from the supply to the load along the line conductor, through the load and back along the neutral conductor. The protective device would be chosen to carry this current.

- However, if a fault occurs – for example, a short circuit to earth between the phase conductor and the earthed metalwork of the load – current will flow from the supply to the load and then through the low resistance protective earthing and bonding of the installation back to the supply.

- This will cause a large current to flow and, in a healthy circuit, the protective device will operate very quickly to remove the danger.

- Fuses, MCBs and RCDs provide earth fault protection, overload protection and short circuit protection where a short circuit is a fault of negligible impedance (call it resistance for now) between live and neutral conductors.

- An overload is a current which exceeds the rated value in an otherwise healthy circuit.

- In all cases the basic requirement for protection is that the fault current should be removed quickly and the circuit isolated.

- The IEE Regulation 411.3.2.2 states that the protective device protecting circuits not exceeding 32A shall have a disconnection time not exceeding 0.4 s.

Further information can be found on pages 130 to 135 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Earthing and bonding

1. Briefly state what we mean by the terms earth, earthing, bonding and protective equipotential bonding and give examples from your own experience.

   Earth means ....

   ....

   Earthing means ....

   ....

   Bonding means ....

   ....

   Protective equipotential bonding means ....

   ....

2. In the spaces below briefly state what we mean by exposed and extraneous conductive parts.

   Exposed conductive parts are ....

   For example ....

   Extraneous conductive parts are ....

   For example ....

3. People are protected from an electric shock in two ways: by basic and fault protection. State what that means. (You can find definitions in Part 2 of the IEE Regulations and on page 133 of *Basic Electrical Installation Work* 5th Edition.)

Basic protection means ....

Fault protection means ....

4. People are protected from touching live parts by basic protection. How is this achieved in practice?

- ....
- ....
- ....
- ....

5. People are protected from touching exposed conductive parts which have become "live" as a result of a fault by fault protection. How is this achieved in practice?

....

....

Wiring systems

Electrical conductors and cables are installed in electrical wiring systems and must be appropriate for their purpose and installed conditions. Typical wiring systems are conduit or trunking systems, metal and plastic, tray systems, specialist cables, SWA, MICC or PVC insulated and sheathed cables. For the situations listed below, identify an appropriate wiring system, typical enclosures and equipment.

Situation 1 A domestic dwelling

Situation 2 A garage repairing cars and trucks

Situation 3 A school or college

Situation 4 A public swimming pool

Further information can be found on pages 124 to 127 and 306 to 311 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Tools and equipment used for electrotechnical applications

1. Identify **six** different hand tools and their applications in the electrotechnical industry. The first example has been done for you:

    1.1. *Insulated side cutters used to cut conductors and cables to length*

    1.2 ....

    1.3 ....

    1.4. ....

    1.5. ....

    1.6. ....

2. Identify **six** different pieces of equipment used in the electrotechnical industry. The first example has been done for you:

    2.1. *Conduit bending machine with vice to cut, bend and set steel conduit*

    2.2. ....

    2.3. ....

    2.4. ....

    2.5. ....

    2.6. ....

3. Electrical power tools on site can save many man hours of hard work. Use bullet points to identify the advantages and disadvantages of each type of power tool below:

230V power tools

Advantages	**Disadvantages**
....	....
....	....
....	....
....	....

110V power tools

Advantages	**Disadvantages**
....	....
....	....
....	....
....	....

Battery operated power tools

Advantages	**Disadvantages**
....	....
....	....
....	....
....	....

Further information can be found on pages 142 to 145 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Safety at work

State the hazards associated with (1) manually lifting heavy objects and (2) working above ground and how you would avoid this hazard at work.

1. Manual lifting hazard ....

....

To reduce the risks associated with manual lifting ....

....

....

....

....

2. Working at heights hazard ....

....

To reduce the risks associated with working at heights ....

....

....

....

....

....

3. Slips, trips and falls are a major cause of accidents at work. Think about your place of work and then state **four** important things that you can do to make it a safer working environment.

- ....
- ....
- ....
- ....

4. Electrical tools and equipment are attractive to casual thieves. How do you and your team protect and store your electrical tools and equipment when working on site?

- ....
- ....
- ....
- ....

Further information can be found on pages 165 to 169 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

1. The efficiency of a small passenger lift motor whose electrical input is 5 kW and output 3 kW is:

a. 0.6% ☐
b. 15.0% ☐
c. 16.6% ☐
d. 60.0%. ☐

2. An insulator is a material in which the electrons are:

a. very large compared with the nucleus ☐
b. positively charged to the nucleus ☐
c. tightly bound to the nucleus ☐
d. loosely bound to the nucleus. ☐

3. A conductor is a material in which the electrons are:

a. very large compared with the nucleus ☐
b. positively charged to the nucleus ☐
c. tightly bound to the nucleus ☐
d. loosely bound to the nucleus. ☐

4. A "good conductor" material has:

a. a negative nucleus in the atoms of the material ☐
b. positive electrons available for current flow ☐
c. free electrons available for current flow ☐
d. no free electrons. ☐

5. A "good insulator" material has:

a. a negative nucleus in the atoms of the material ☐
b. positive electrons available for current flow ☐
c. free electrons available for current flow ☐
d. no free electrons. ☐

6. Electricity is generated in a modern power station at:

a. 230 V ☐
b. 400 V ☐
c. 25 kV ☐
d. 132 kV ☐

7. Electricity is distributed on the National Grid at:

a. 230 V ☐
b. 400 V ☐
c. 25 kV ☐
d. 132 kV ☐

8. The highest transmission line voltage in Britain is:

a. 240 kV ☐
b. 415 kV ☐
c. 400 kV ☐
d. 1000 kV ☐

9. The voltage used for transmission on the Grid is transformed to a very high voltage because:
- a. this increases the line current ☐
- b. the p.f. of the line is improved at high values ☐
- c. the line resistance is increased ☐
- d. the line efficiency is increased. ☐

10. The national transmission network in the United Kingdom is known as:
- a. National Power ☐
- b. the National Grid System ☐
- c. the National Coal Board ☐
- d. the British Transmission System. ☐

11. The current taken by a 10V resistor when connected to a 230V supply is:
- a. 41 mA ☐
- b. 2.3 A ☐
- c. 23 A ☐
- d. 230 A ☐

12. The resistance of an element which takes 12 A from a 230V supply is:
- a. 2.88 Ω ☐
- b. 5 Ω ☐
- c. 12.24 Ω ☐
- d. 19.16 Ω ☐

13. A 12 Ω lamp was found to be taking a current of 2 A at full brilliance. The voltage across the lamp under these conditions was:
- a. 6V ☐
- b. 12V ☐
- c. 24V ☐
- d. 240V ☐

14. Resistors of 6 and 3 Ω are connected in series. The combined resistance value will be:
- a. 2 Ω ☐
- b. 3.6 Ω ☐
- c. 6.3 Ω ☐
- d. 9 Ω ☐

15. Resistors of 3 and 6 Ω are connected in parallel. The equivalent resistance will be:
- a. 2 Ω ☐
- b. 3.6 Ω ☐
- c. 6.3 Ω ☐
- d. 9 Ω ☐

16. The SI units of length, resistance, and power are:
- a. millimetre, ohm, kilowatt ☐
- b. centimetre, ohm, watt ☐
- c. metre, ohm, watt ☐
- d. kilometre, ohm, kilowatt. ☐

17. The resistance of 100 m of 1 mm^2 cross-section copper cable of resistivity 17.5×10^{-9} Ωm will be:
- a. 1.75 mΩ ☐
- b. 1.75 Ω ☐
- c. 17.5 Ω ☐
- d. 17.5 kΩ ☐

18. A temperature of 25° on the Celsius scale is equal to a temperature on the Kelvin scale of:
a. −248 K ☐
b. 187 K ☐
c. 248 K ☐
d. 298 K ☐

19. The absolute zero, 0 K, is equal to a temperature reading on the Celsius scale of:
a. −273°C ☐
b. −100°C ☐
c. 32°C ☐
d. 212°C ☐

20. If we assume the acceleration due to gravity to be 10 m/s^2 a 50 kg bag of cement falling to the ground will exert a force of:
a. 5N ☐
b. 50N ☐
c. 100N ☐
d. 500 N ☐

21. A current flowing through a solenoid sets up a magnetic flux. If an iron core is added to the solenoid while the current is maintained at a constant value the magnetic flux will:
a. remain constant ☐
b. totally collapse ☐
c. decrease in strength ☐
d. increase in strength. ☐

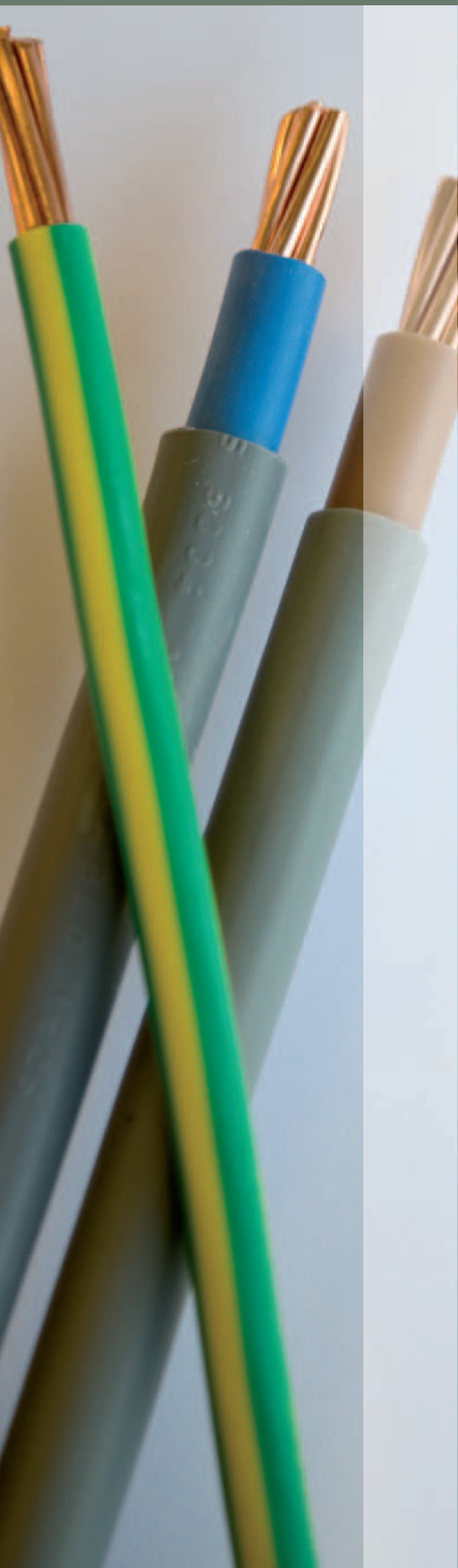
22. The core of a transformer is laminated to:
a. reduce cost ☐
b. reduce copper losses ☐
c. reduce hysteresis loss ☐
d. reduce eddy current loss. ☐

23. The transformation ratio of a step-down transformer is 20:1. If the primary voltage is 230V the secondary voltage will be:
a. 2.3V ☐
b. 11.5V ☐
c. 20V ☐
d. 23V ☐

24. Three resistors of 24, 40 and 60 Ω are connected in series. The total resistance will be:
a. 12 Ω ☐
b. 26.4 Ω ☐
c. 44 Ω ☐
d. 124 Ω ☐

25. Resistors of 24, 40 and 60 Ω are connected together in parallel. The effective resistance of this combination will be:
a. 12 Ω ☐
b. 26.4 Ω ☐
c. 44 Ω ☐
d. 124 Ω ☐

Answers to Worksheets 1 to 11



Worksheet 1

1. Mass – amount of material
   Weight – force exerted by mass
2. 981 N
3. (a) Ampere, A, mA μA, (b) Watt, W, kW, MW, (c) Kelvin, K, 273 K, 100°C, 20°C
4. 700 mΩ
5. See Handout 4
6. 83.3%
7. 700W

Worksheet 2

1. See Handout 5
2. See Handout 5
3. See Handout 5
4. See Handout 6
5. See Handout 7

Worksheet 3

1. Series $R_T = 18\,\Omega$ $I_T = 0.66$ A
   Parallel $R_T = 4\Omega$ $I_T = 3$ A
2. See Handouts 8 and 9
3. Series $R_T = 35\,\Omega$ $I_T = 1$ A
   Parallel $R_T = 2.86\,\Omega$ $I_T = 12.24$ A.

Worksheet 4

1.
2. At Lecturer's discretion
3.
4. Like poles repel, unlike poles attract.

Worksheet 5

1. See Handout 11
2. See Handout 11
3. At Lecturer's discretion.

Worksheet 6

1.
2. see Handout 13 and Figs 6.1 and 6.2 of *Basic Electrical Installation Work* 5th Edition, but answers at Lecturer's discretion
3.

Worksheet 7

1 to 5 at Lecturer's discretion – see Handout 14.

Worksheet 8

1 to 4 at Lecturer's discretion.

Worksheet 9

1 and 2 at Lecturer's discretion.

3. Consider availability of supply, duration of supply, power and torque available, will it be safe in use, what are the potential hazards of, for example power supply, extension leads, acceptability on site, etc.

Worksheet 10

1. Sprains, strains and trap injuries – use mechanical lifting aid for heavy objects, use correct procedures.
2. Falling hazard – use only company approved equipment, steps fully open, ladders lashed, footed and at correct angle. Requirements of new work at Height Regulations: 2005.
3. See "precautions taken to control risks" page 154 of *Basic Electrical Installation Work*.
4. Secure, locked store, company vehicle, etc.

Worksheet 11

1 = d	**10 = b**	**19 = a**
2 = c	**11 = c**	**20 = d**
3 = d	**12 = d**	**21 = d**
4 = c	**13 = c**	**22 = d**
5 = d	**14 = d**	**23 = b**
6 = c	**15 = a**	**24 = d**
7 = d	**16 = c**	**25 = a**
8 = c	**17 = b**	
9 = d	**18 = d**	

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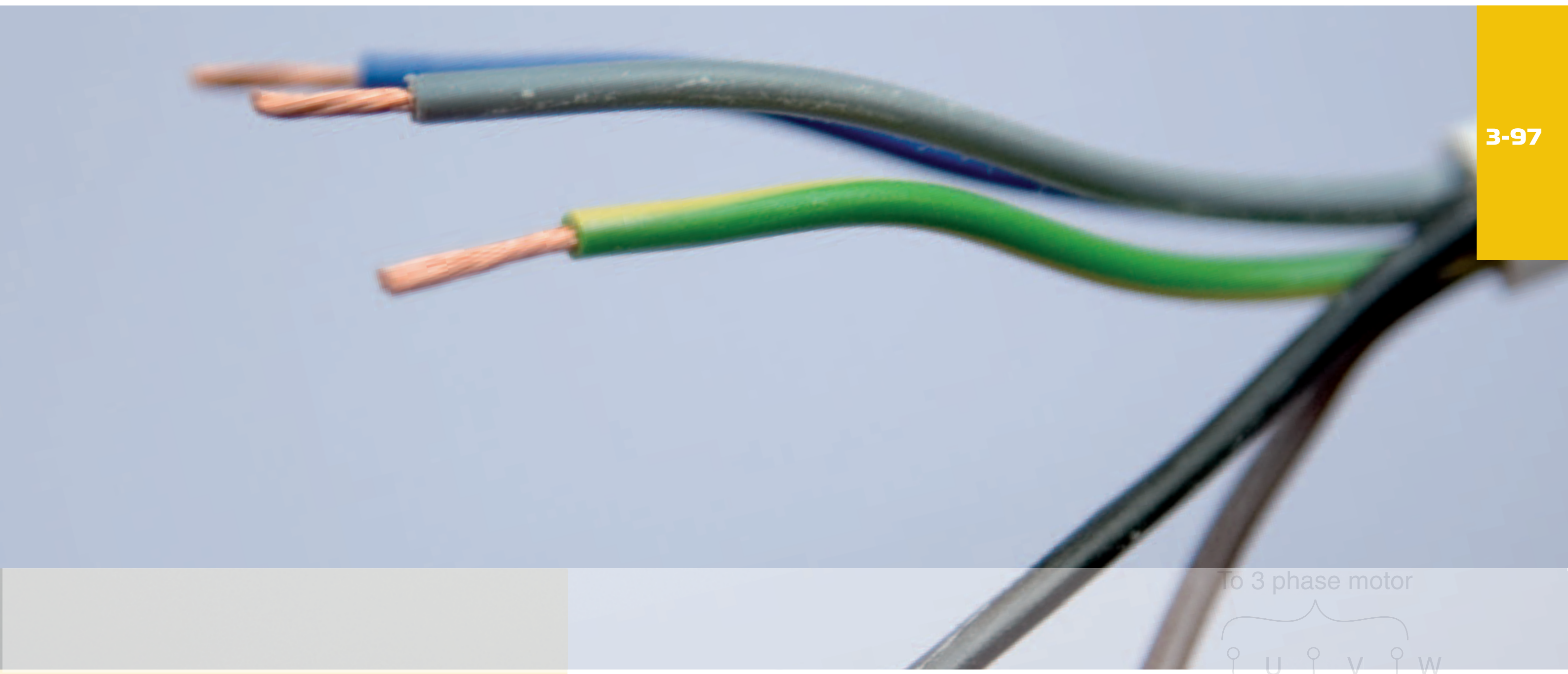
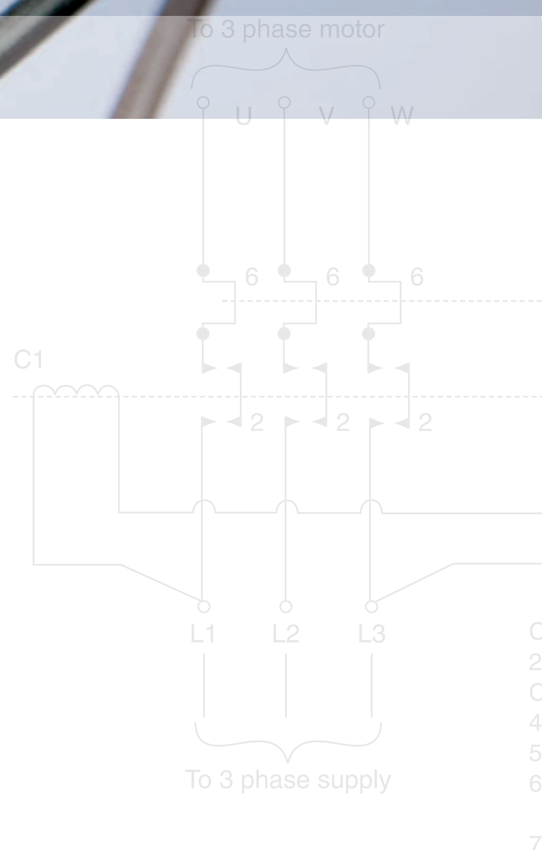
3

Core Unit 3, Level 2
Applications of Health and Safety and Electrical Principles (Stage 2)





Level 2 – Certificate in Electrotechnical Technology

Contents

Avoiding accidents in the workplace

The most common categories of risk and causes of accidents in the workplace are:

- slips, trips and falls
- manual handling; that is, moving objects by hand
- using equipment, machinery or tools
- storage of goods and materials which then become unstable
- fire
- electricity
- mechanical handling.

To control the risk of an accident we usually take the following precautions:

- eliminate the cause
- substitute a procedure or product with less risk
- enclose the dangerous situation
- put guards around the hazard
- use safe systems of work
- supervise, train and give information to staff
- if the hazard cannot be removed or minimized then the employer must provide PPE.

A Hazard is something with the **potential to cause harm**; for example, electric or pneumatic tools working above ground level, wet or uneven floors, rotating parts.

A Risk is the **possibility of harm actually being done**. Is it a high, low or medium risk? Who is at risk, the office staff, electricians, the public? Is the risk adequately controlled?

A positive personal attitude to safety reduces accidents at work. Always work and act responsibly and safely to protect yourself and others. Be aware of the hazards around you, the protection available to you and the means of preventing accidents.

3-99

Risk assessment, the process

We have already seen in Unit 1 that an employer must carry out risk assessments as a part of a robust Health and Safety Policy.

The Management of Health and Safety at Work Regulations 1999 tell us that employers must systematically

- examine the workplace hazards
- examine the work activities
- examine the safety systems and procedures
- examine the management of safety in the workplace in order to control health and safety through a process of "risk assessment".

The aim of the risk assessment process is to minimize risk (HSE publication HSG(65)).

A record of all significant risk assessment findings must be kept in a safe place.

Carry out a simply risk assessment in the College workshops or another place, as directed by your Lecturer, using the Hazard Risk Assessment form overpage (Fig. 3.1). (You may need more than one copy.)

HAZARD RISK ASSESSMENT	FLASH-BANG ELECTRICAL CO.
For Company name or site: .... Address:	Assessment undertaken by: .... Signed: .... Date: ....
STEP 5 Assessment review date:	
STEP 1 List the hazards here	STEP 2 Decide who might be harmed
STEP 3 Evaluate (what is) the risk – is it adequately controlled? State risk level as low, medium or high	STEP 4 Further action – what else is required to control any risk identified as medium or high?

FIGURE 3.1
Hazard risk assessment standard form.

Further information can be found on pages 155 to 160 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

HAZARD RISK ASSESSMENT	**FLASH-BANG ELECTRICAL CO.**
For Company name or site: ______________ Address: ______________ ______________ ______________	Assessment undertaken by: ______________ ______________ Signed: ______________ Date: ______________
STEP 5 Assessment review date: ______________	
STEP 1 List the hazards here	STEP 2 Decide who might be harmed
STEP 3 Evaluate (what is) the risk – is it adequately controlled? State risk level as low, medium or high	STEP 4 Further action – what else is required to control any risk identified as medium or high?

Safe working above ground level

Working above ground level is hazardous because there is a risk of falling. If the working platform is appropriate for the purpose, properly erected and in good condition, then the risk is low.

For each of the three pieces of access equipment listed below, state what you would check for before using that particular piece of equipment in order to establish that it was safe to use. For example, is there any obvious sign of damage; is it stable; must it be erected at a particular angle; must it be secured in some way, and if so, how? Are guard rails or toe boards required and why?

Give an example of a typical application for each piece of equipment:

Stepladder

Typical use ....

....

(a) Safety checks before use (see above) ....

....

....

(b) Safety precautions to be observed when setting up this equipment ....

....

....

(c) Method of securing or stabilizing this piece of equipment ....

....

....

Extension ladder

Typical use ....

....

(a) Safety checks before use (see above) ....

....

....

(b) Safety precautions to be observed when setting up this equipment ....

....

....

(c) Method of securing or stabilizing this piece of equipment ....

....

....

Mobile scaffold tower

Typical use ....

....

(a) Safety checks before use (see above) ....

....

....

(b) Safety precautions to be observed when setting up this equipment ....

....

....

(c) Method of securing or stabilizing this piece of equipment ....

....

....

Further information may be found on pages 167 to 169 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Manual handling

There have been so many injuries over the years as a result of lifting, transporting or supporting loads by hand or bodily force that the Health and Safety Executive has introduced new legislation: the Manual Handling Operations Regulations 1992.

- If a job involves considerable manual handling, workers must be trained in the correct lifting procedure.
- Loads must not be lifted manually if it is more appropriate to use a mechanical aid.
- Always use a trolley, sack truck or wheelbarrow when these are available.
- Use **good manual lifting** techniques if the load must be lifted manually and avoid jerky movements.
- Only lift and carry what you can manage easily.
- Wear gloves to avoid rough or sharp edges.

Good manual lifting techniques

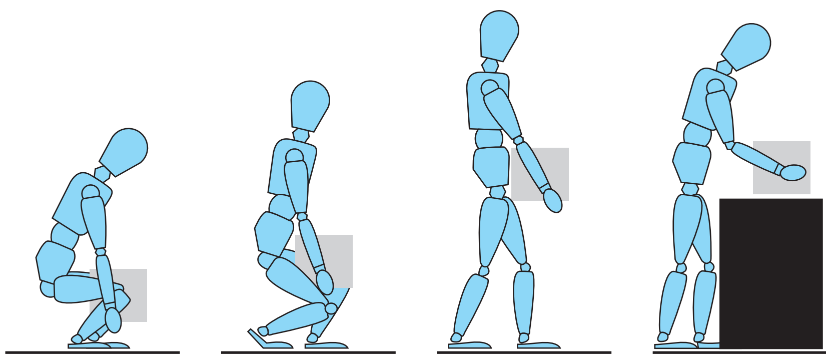


FIGURE 3.2
Correct manual lifting and carrying procedure.

When manually lifting objects from the floor:

- bend at the hips and knees to get down to the object
- grasp the object firmly
- take account of its centre of gravity
- keep your back straight and head erect, use the powerful leg muscles to raise the object
- carry the load close to the body (Fig. 3.2).

Further information can be found on pages 165 to 167 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Manual handling

Give consideration to the case studies below and give answers as brief bullet points.

1. You are working on a large extension to an existing Supermarket which is open. Let us imagine that it is an existing Supermarket that is being converted into a Superstore. Your supervisor has ordered:

   (a) several bundles of sheet conduit

   (b) about 20 coils of cable

   (c) several lengths of 75 × 75 steel trunking

   (d) ten recessed modular light fittings packed individually in heavy card.

The delivery lorry unloads them on to the car park while the supervisor checks and signs the dispatch note. As the apprentice, you are then asked by the supervisor to move all the items into the safe store, which is a container, situated 100 m further down the car park. State how you would move these electrical products safely and discuss security considerations.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

2. You have been sent to work at your company's Head Office stores, which are on a modern Industrial Estate. While you were away collecting everyone's lunch order a very large delivery was made to the store's yard. The manager tells you to eat your lunch quickly and get the delivered goods into the stores area before it rains. The delivery consists of about 50 assorted rolls of cable, dozens of boxes of fluorescent tubes, five boxes about 25 cm cubed containing very heavy chain and 10 electric motors, three of which are large and look very heavy. Use bullet points to describe how you would set about moving all this equipment inside before it rains.

Electrical isolation and lock off

- The IEE Regulations tell us that every circuit must be provided with a means of isolation.

- The Electricity at Work Regulations tell us that before work commences on electrical equipment it must be disconnected from the source of supply and that the disconnection must be secure.

- A small padlock will ensure the security of the disconnection.

- Where a test instrument or voltage indicator is used to prove the supply dead, the same device must be tested to prove it is still working.

- The test leads and probes of the test instrument must comply with the Health and Safety Executive Guidance Note 38, giving adequate protection to the user.

- To deter anyone from reconnecting the supply, a notice must be fixed on the isolator saying "Danger – Electrician at Work".

A suitable electrical isolation procedure is shown on the next page, which you should practise in the workshop under the guidance of your lecturer (Fig. 3.3).

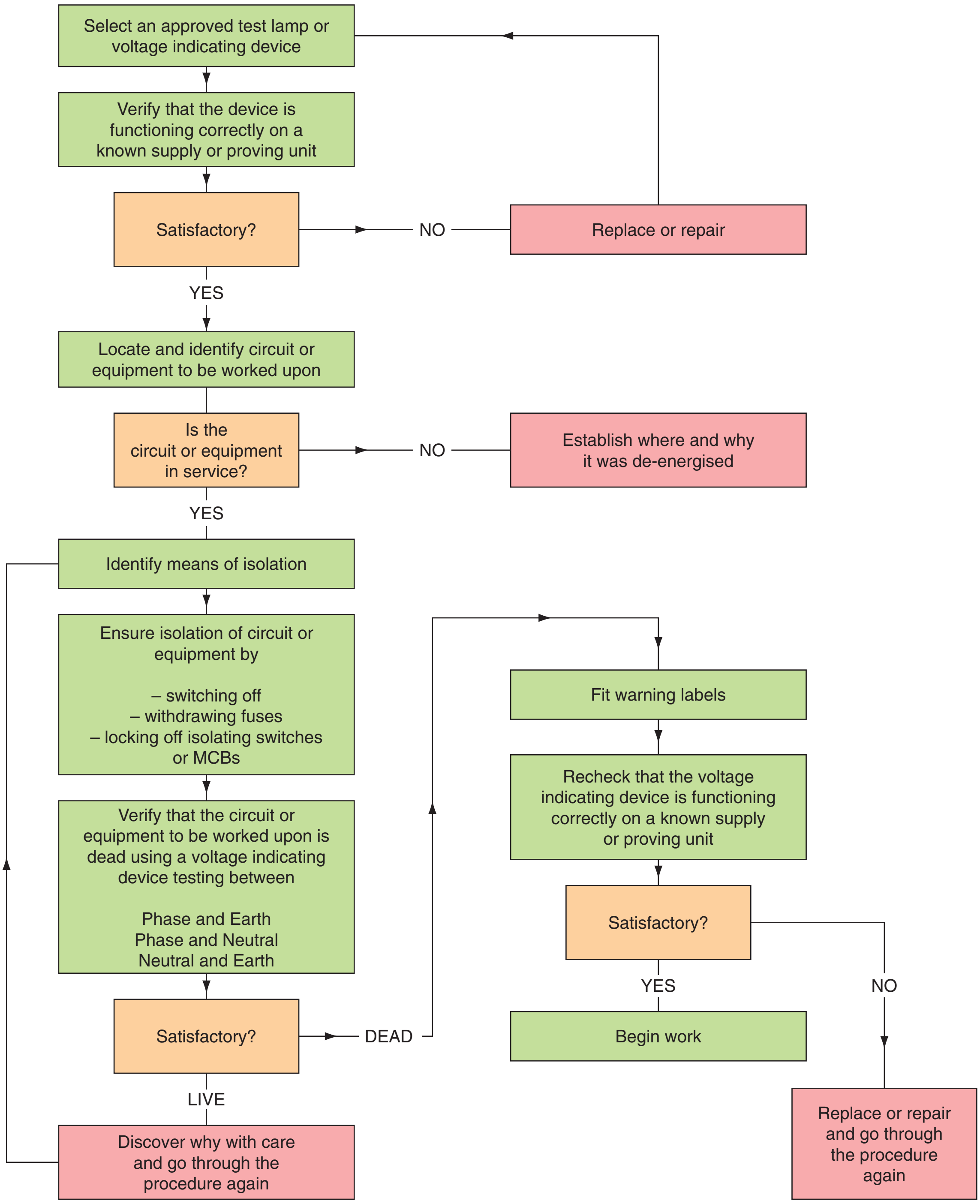


FIGURE 3.3
Flowchart for a secure isolation procedure.

Further information can be found on pages 169 to 172 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

A.C. circuits

1. In an a.c. circuit the total opposition to current flow is made up of resistance and reactance. State the effects of resistance, capacitive reactance and inductive reactance in an a.c. circuit.

Resistance ....

....

Capacitive Reactance ....

....

Inductive Reactance ....

....

2. Sketch the phasor diagram of current and voltage in each circuit.

Pure resistance	**Pure capacitance**	**Pure inductance**

3. Define the meaning of power factor in an a.c. circuit.

Power factor is ....

....

....

....

....

....

....

....

....

....

4. What do we mean by "bad" power factor? Use a phasor diagram to illustrate your answer below:

Further information can be found on pages 194 to 204 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Electrical machines: Basic operating principles

Use a sketch and bullet points to describe the **basic principle of operation** of the following **four** electrical machines.

1. **Electrical relay** (*Note*: this is a simple electrical switch)

Further information can be found on pages 216 to 217 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

2. **D.C. Motor** (*Note*: the syllabus is looking for a simple, basic description)

Further information can be found on pages 207 to 208 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

3. **A.C. Motor** (*Note*: the syllabus is looking for a simple basic description)

4. **Transformer** (*Note*: also explain how the turns ratio affects the voltage)

Further information can be found on pages 210 to 214 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Polyphase: Three-phase a.c. supplies

1. Use bullet points and a sketch to describe below how a three-phase a.c. supply is produced. (*Note*: the method is very similar to the simple a.c. generator described in Handout 4 of Unit 2).

Further information can be found on page 222 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

2. The phase windings of a three-phase supply may be connected in Star or Delta. In the space below show **three** windings connected first in Star and then in Delta and state the formulae for current and voltage in both cases.

Star connection	Delta connection

3-115

Further information can be found on page 220 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

3. In the space below use a labelled diagram to show how electrical energy is transmitted and distributed from the power station to the end user comprising:

   (i) a large industrial consumer connected to the supply at 33 kV

   (ii) a local college connected to the supply at 11 kV

   (iii) a garage showroom connected to the supply at 400V

   (iv) three detached houses connected to the supply at 230V

   Identify overhead and underground cables and all voltage levels.

4. In the space below use a labelled diagram to show how six similar 230 V loads would be connected to a 400 V three-phase supply. Show the new harmonized cable colours and take "balancing" into consideration.

Further information can be found on pages 225 to 226 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Circuit protective devices

The provision of protective devices is fundamental to the whole concept of the safe use of electricity in buildings.

Overcurrent means a current exceeding the rated value. Fuses and MCBs are protective devices which give overcurrent protection when situated in the live conductor.

The protective devices selected will depend upon the:

- prospective fault current
- circuit load characteristics
- current carrying capacity of the cable
- disconnection time limitations.

The essential requirements for a device selected to protect against overcurrent are that it:

- operates automatically
- has a current rating related to the circuit design current
- will disconnect the circuit within the design parameters
- has adequate breaking capacity
- is suitably located and identified.

Further information can be found on pages 239 to 244 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Circuit protective devices and earth fault protection

1. Complete the statement below:

   An electrical circuit needs protective devices to protect against

   (a) ....

   (b) ....

   (c) ....

2. Protective earthing and bonding in an electrical installation is an essential part of protection for the purpose of safety and therefore in the electrotechnical industry we talk about the metalwork of buildings and equipment in very specific terms. Define what is meant by the following and give an example:

   Earth is ....

   ....

   A bonding conductor is ....

   ....

   A CPC (circuit protective conductor) is ....

   ....

   Exposed conductive parts are ....

   ....

   Extraneous conductive parts are ....

   ....

3. State the action of a fuse (a) in normal conditions and (b) under fault conditions:

   (a) In normal circuit conditions a fuse ....

   ....

   ....

   ....

   (b) Under fault conditions a fuse ....

   ....

   ....

   ....

4. Describe (a) what we mean by discrimination and (b) how this is achieved when a number of devices are fitted between the supply and the load:

   (a) discrimination means ....

   ....

   ....

   ....

   (b) circuit discrimination is achieved by ....

   ....

   ....

   ....

Further information may be found on pages 234 to 247 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

1. **Hazard may be defined as:**
   a. anything that can cause harm ☐
   b. the chance, large or small, of harm actually being done ☐
   c. someone who has the necessary training and expertise to safely carry out an activity ☐
   d. the rules and regulations of the working environment. ☐

2. **Risk may be defined as:**
   a. anything that can cause harm ☐
   b. the chance, large or small, of harm actually being done ☐
   c. someone who has the necessary training and expertise to safely carry out an activity ☐
   d. the rules and regulations of the working environment. ☐

3. **Hazard Risk Assessment is:**
   a. the harm which might be done to an employee not wearing PPE ☐
   b. the hazard created when someone lifts a very heavy object ☐
   c. the process of systematically examining the workplace for possible dangers ☐
   d. the risk of harm being done to someone in the workplace. ☐

4. **The angle of a ladder to the building upon which it is resting should be in the proportions of:**
   a. 1 up to 4 out ☐
   b. 4 up to 75 out ☐
   c. 4 up to 1 out ☐
   d. 75 up to 4 out. ☐

5. **The angle which a correctly erected ladder should make with level ground is:**
   a. 41° ☐
   b. 45° ☐
   c. 57° ☐
   d. 75° ☐

6. **For good stability mobile towers must have a base width to tower height ratio of:**
   a. 1:2 ☐
   b. 1:3 ☐
   c. 1:4 ☐
   d. 1:5 ☐

7. **To avoid back injuries when manually lifting heavy weights from ground level a worker should:**
   a. bend both legs and back ☐
   b. bend legs but keep back straight ☐
   c. keep legs straight but bend back ☐
   d. keep both legs and back straight. ☐

8. **An a.c. series circuit has an inductive reactance of 4 Ω and a resistance of 3 Ω. The impedance of this circuit will be:**
   a. 5 Ω ☐
   b. 7 Ω ☐
   c. 12 Ω ☐
   d. 25 Ω ☐

9. An a.c. series circuit has a capacitive reactance of 12 Ω and a resistance of 9 Ω. The impedance of this circuit will be:

a. 3 Ω ☐
b. 15 Ω ☐
c. 20 Ω ☐
d. 108 Ω ☐

10. The inductive reactance of a 100 mH coil when connected to 50 Hz will be:

a. 0.5 Ω ☐
b. 4.5 Ω ☐
c. 5.0 Ω ☐
d. 31.416 Ω ☐

11. The capacitive reactance of a 100 μF capacitor connected to a 50 Hz supply will be:

a. 0.5 Ω ☐
b. 5.0 mΩ ☐
c. 31.83 Ω ☐
d. 31415.93 Ω ☐

12. Two a.c. voltages V_1 and V_2 have values of 20 and 30V respectively. If V_1 leads V_2 by 45° the resultant voltage will be:

a. 16V at 24° ☐
b. 45V at 90° ☐
c. 46V at 18° ☐
d. 50V at 45° ☐

13. Power factor is defined as the:

a. sine of the phase angle between the current and voltage ☐
b. cosine of the phase angle between the current and voltage ☐
c. tangent of the phase angle between the current and voltage ☐
d. reactance of the phase angle between the current and voltage. ☐

14. The power factor of a circuit in which the current and voltage are in phase is:

a. 0.8660 ☐
b. 0.9396 ☐
c. 0.9848 ☐
d. 1.0000 ☐

15. The power factor of a circuit in which the current leads the voltage by 20° is:

a. 0.7660 ☐
b. 0.8660 ☐
c. 0.9396 ☐
d. 0.9848 ☐

16. The power factor of a circuit in which the current lags the voltage by 20° is:

a. 0.7760 ☐
b. 0.8660 ☐
c. 0.9396 ☐
d. 0.984 ☐

17. In an inductive circuit, having a p.f. of 0.5, the current lags the voltage by an angle of:

a. 10° ☐
b. 20° ☐
c. 30° ☐
d. 60° ☐

18. In a capacitive circuit, having a p.f. of 0.8660 the current leads the voltage by an angle of:

a. 10° ☐
b. 20° ☐
c. 30° ☐
d. 40°. ☐

19. A circuit having a "good" p.f. would have a value of:

a. better than 0.9 ☐
b. better than 0.7 ☐
c. less than 0.5 ☐
d. less than 0.3. ☐

20. Power factor improvement is often achieved by connecting a device across the mains supply. The device is called:

a. a resistor ☐
b. an inductor ☐
c. a capacitor ☐
d. an impedance. ☐

21. A laminated cylinder of silicon steel with copper or aluminium bars slotted into holes around the circumference and short circuited at each end of the cylinder, is one description of:

a. a cage rotor ☐
b. an electromagnet ☐
c. a linear motor ☐
d. an induction motor. ☐

22. A magnetically operated electrical switch contact is one description of:

a. an a.c. motor ☐
b. an electrical relay ☐
c. an electrical circuit ☐
d. an electrical transformer. ☐

23. The core of a transformer is laminated to:

a. reduce cost ☐
b. reduce copper losses ☐
c. reduce hysteresis loss ☐
d. reduce eddy current loss. ☐

24. The transformation ratio of a step-down transformer is 20:1. If the primary voltage is 230V the secondary voltage will be:

a. 2.3V ☐
b. 11.5V ☐
c. 23V ☐
d. 46V ☐

25. A step-down transformer has a turns ratio of 10:1. If the primary voltage is 100V, the secondary voltage will be:

a. 1V ☐
b. 10V ☐
c. 100V ☐
d. 1000V ☐

26. A step-up transformer has a turns ratio of 1:10. If the primary voltage is 100V the secondary voltage will be:

a. 1V ☐
b. 10V ☐
c. 100V ☐
d. 1000V ☐

27. A transformer is connected to the 230V mains supply so that it might supply an instrument operating at 2V. The turns ratio of this transformer is:

a. 1:46 ☐
b. 46:1 ☐
c. 1:115 ☐
d. 115:1 ☐

28. An isolating transformer can be found:

a. on construction sites operating individual power tools ☐
b. in large commercial power stations ☐
c. in sub-stations connecting power lines to the National Grid ☐
d. in an electric shaver unit. ☐

29. A Star connected supply has a line voltage of 400V and a line current of 100A. The phase voltage and current will be approximately:

a. 230V and 100A ☐
b. 230V and 57.7A ☐
c. 400V and 57.7A ☐
d. 400V and 100A ☐

30. A Delta connected supply has a line voltage of 400V and a line current of 100A. The phase voltage and current will be approximately:

a. 230V and 100A ☐
b. 230V and 57.7A ☐
c. 400V and 57.7A ☐
d. 400V and 100A ☐

31. To "balance" nine similar single-phase loads across a three-phase supply would require:

a. four single-phase loads to be connected to each of two phases of the three-phase supply and one single-phase load to the neutral ☐
b. three single-phase loads to be connected to each phase of the three-phase supply ☐
c. two single-phase loads to be connected to each phase of the three-phase supply and three single-phase loads connected to neutral ☐
d. one single-phase load connected to each phase of the three-phase supply and six single-phase loads connected to neutral. ☐

32. An overload current may be defined as:

a. a current in excess of at least 15A ☐
b. a current which exceeds the rated value in an otherwise healthy circuit ☐
c. an overcurrent resulting from a fault between live and neutral conductors ☐
d. a current in excess of 60A. ☐

33. A short circuit may be defined as:

a. a current in excess of at least 15A ☐
b. a current which exceeds the rated value in an otherwise healthy circuit ☐
c. an overcurrent resulting from a fault between live and neutral conductors ☐
d. a current in excess of 60A. ☐

34. "Under fault conditions the protective device nearest to the fault should operate leaving other healthy circuits unaffected". This is one definition of:
a. fusing factor ☐
b. effective discrimination ☐
c. a miniature circuit breaker ☐
d. a circuit protective conductor (CPC). ☐

35. The overcurrent protective device protecting socket outlet circuits not exceeding 32 A must operate within:
a. 0.02 s ☐
b. 0.4 s ☐
c. 5 s ☐
d. 45 s ☐

36. Any socket outlet with a rated current not exceeding 20 A for use by ordinary people and intended for general use must have:
a. overcurrent protection ☐
b. a means of isolation ☐
c. RCD protection ☐
d. protective equipotential bonding. ☐

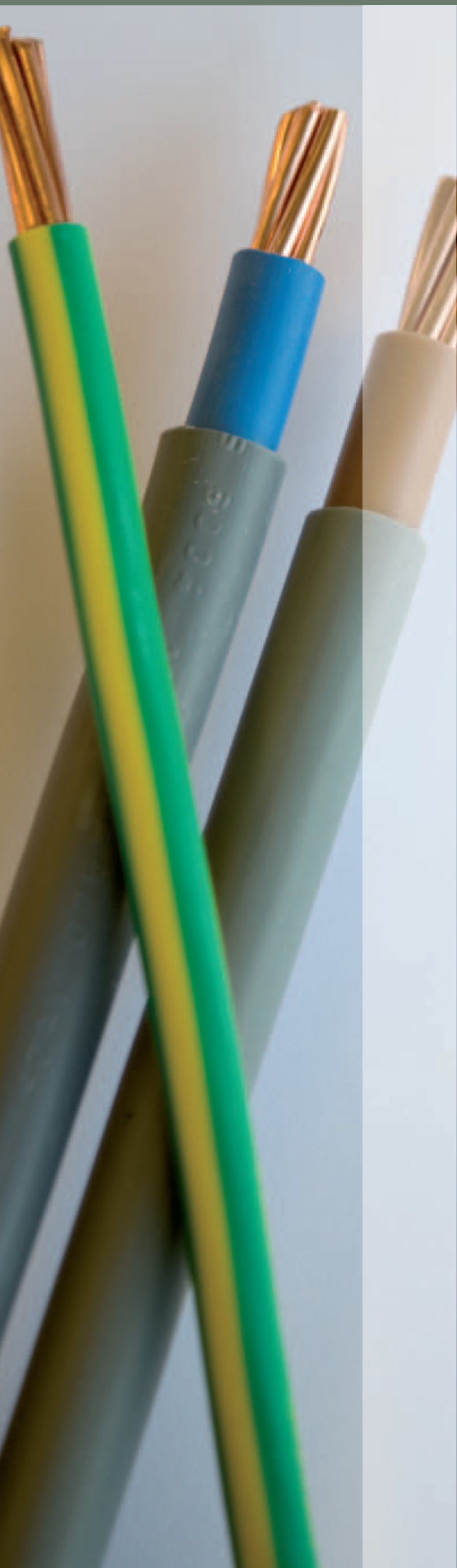
37. The metal structural steelwork of a building is called:
a. the general mass of earth ☐
b. the circuit protective conductor (CPC) ☐
c. exposed conductive parts ☐
d. extraneous conductive parts. ☐

38. The protective conductor connecting exposed conductive parts of equipment to the main earthing terminal is called:
a. the general mass of earth ☐
b. the circuit protective conductor (CPC) ☐
c. exposed conductive parts ☐
d. extraneous conductive parts. ☐

39. The trunking and conduit of an electrical installation are called:
a. the general mass of earthing ☐
b. the circuit protective conductor (CPC) ☐
c. exposed conductive parts ☐
d. extraneous conductive parts. ☐

40. The metalwork of a piece of electrical equipment is called:
a. the general mass of earth ☐
b. the circuit protective conductor (CPC) ☐
c. exposed conductive parts ☐
d. extraneous conductive parts. ☐

Answers to Worksheets 1 to 8



Worksheet 1

Carry out a risk assessment in an area identified by the Lecturer.

Worksheet 2

It would be best if this activity was carried out in the workshop.

We are looking for appropriate checks to be made before erection of the equipment, e.g. damage, stepladders must be on firm level ground and stay locked in position. Extension ladders at the correct angle 4:1 and a minimum overlap of two rungs. Mobile scaffold with guard rail and toe boards fitted – wheels locked. Consideration of outriggers dependent upon height. Consideration of securing the equipment.

Worksheet 3

1. Answers at Lecturer's discretion, e.g. is this a job for one trainee? Two apprentices maybe.
   General consideration – the conduit and trunking are heavy and the fittings are delicate. Who has got the key to the store and how will the security of the store be maintained once opened with the goods on the car park 100 m away? The conduit and trunking could easily be carried by two trainees, one at each end and bundles could be split if necessary. The boxes of fittings could be carried two or three at a time and the cable drums in the same way. However, this is both a building site and a working Supermarket. What is around that could be borrowed for transportation of these items? Has the main contractor got a sack truck or is there a Supermarket trolley available? These questions are posed to provide the opportunity for a general discussion on manual handling and attitudes to safety.

2. Answers at Lecturer's discretion – some objects are
   heavy – what is available to mechanically move heavy objects around the stores – a flat bed truck, a sack truck. Consider first anything that may be damaged by the threatened rain – check with the stores manager where individual items should be placed in the store – always plan ahead to avoid unnecessary or repeated movement of heavy loads.

Worksheet 4

1 to 4 answers at Lecturer's discretion.

Worksheet 5

1 to 4 answers at Lecturer's discretion.

Worksheet 6

1 to 4 answers at Lecturer's discretion.

Worksheet 7

1. overload current, short circuit current, earth faults.

2 to 4 answers at Lecturer's discretion.

Worksheet 8 (MC questions)

1 = a	**11 = c**	**21 = a**	**31 = b**
2 = b	**12 = c**	**22 = b**	**32 = b**
3 = c	**13 = b**	**23 = d**	**33 = c**
4 = c	**14 = d**	**24 = b**	**34 = b**
5 = d	**15 = c**	**25 = b**	**35 = b**
6 = b	**16 = c**	**26 = d**	**36 = a and c**
7 = b	**17 = d**	**27 = d**	**37 = d**
8 = a	**18 = c**	**28 = d**	**38 = b**
9 = b	**19 = a**	**29 = a**	**39 = c**
10 = d	**20 = c**	**30 = c**	**40 = c**

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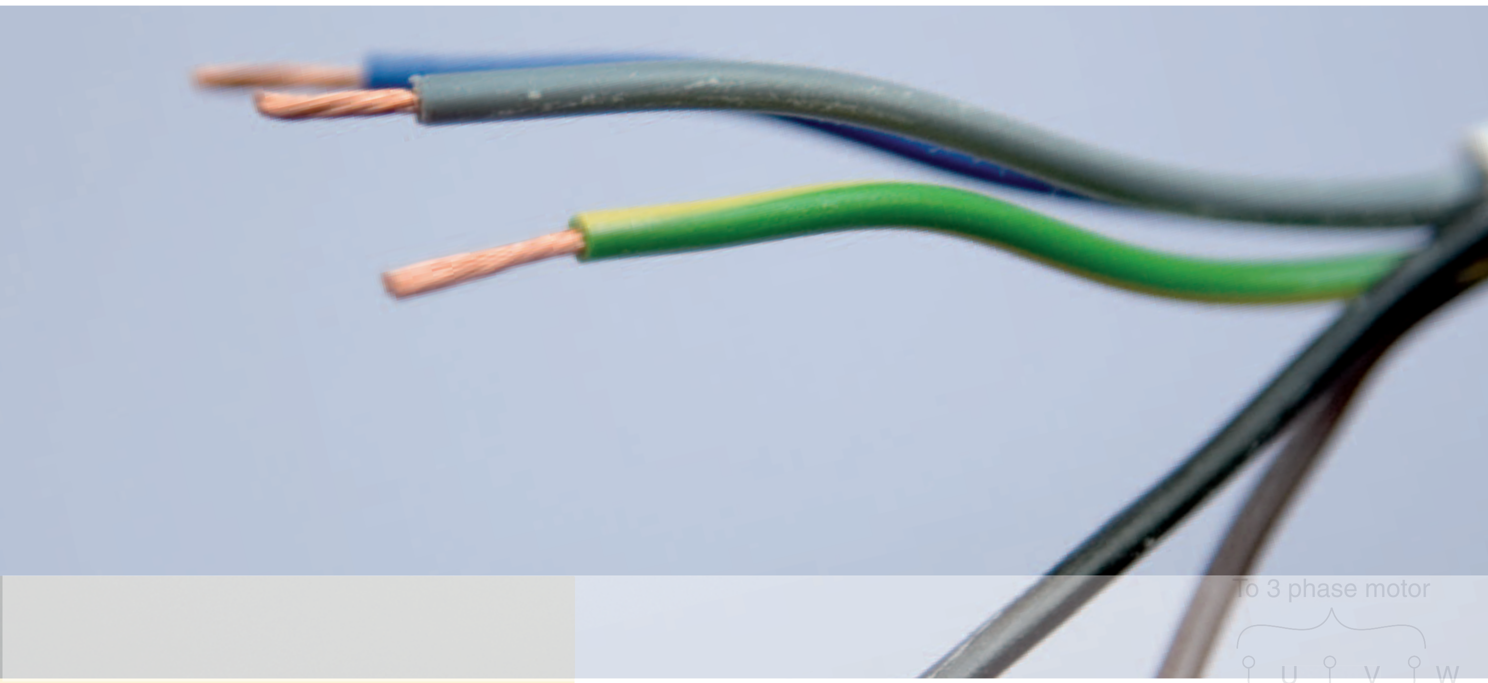
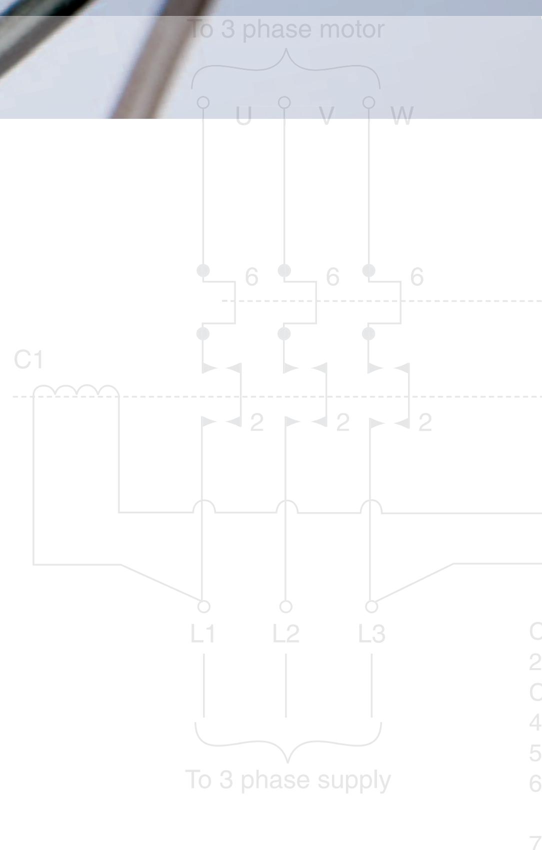
4

Occupational Unit 4, Level 2 Electrical Installation (Buildings and Structures)





Level 2 – Certificate in Electrotechnical Technology

Contents

EAW regulations and codes of practice

The Electricity at Work (EAW) Regulations came into force on the 1st April 1990. The purpose of the Regulations is to require precautions to be taken against the risk of death or personal injury from electricity in work activities. The full text of the Regulations is set out in the Statutory Instrument 1989 No. 635 available from HMSO. However, if you are not involved in the mining or quarry industry or systems for public electricity supply or explosion protection, then the Memorandum of Guidance on the EAW Regulations 1989 available from the Health and Safety Executive (HSE) is a very readable booklet giving guidance on the EAW Regulations.

The EAW Regulations are made under the Health and Safety at Work (HSW) Act 1974 and are statutory regulations. In the introduction of Section 7, it sets out the position of the IEE Regulations in the following terms:

The Institution of Electrical Engineers Regulations for Electrical Installations (the IEE Wiring Regulations) are non-statutory regulations relating principally to the design, selection, erection and inspection and testing of electrical installations. The IEE Wiring Regulations is a code of practice which is widely recognized and accepted in the UK and compliance with them is likely to achieve compliance with relevant aspects of the EAW Regulations 1989.

If a contract specifies that the work will be carried out in accordance with BS 7671, then this would be legally binding and the IEE Wiring Regulations then become a legal requirement of the contract.

The IEE Wiring Regulations (BS 7671: 2008) are compliant with European Standards. British Standards, having a BS EN number, refers to a European harmonized standard and all such standards will become common throughout Europe. The harmonized standards are co-ordinated by representatives from all countries in the European Union by an organization known as CENELEC.

To assist workers in the electrotechnical industry with their understanding of the relevant regulations, many guidance booklets have been published, particularly:

- The On Site Guide published by the IEE
- Guidance Note 1: Selection and Erection of Equipment
- Guidance Note 2: Isolation and Switching
- Guidance Note 3: Inspection and Testing
- Guidance Note 4: Protection Against Fire
- Guidance Note 5: Protection Against Electric Shock
- Guidance Note 6: Protection Against Overcurrent
- Guidance Note 7: Special Locations
- Guidance Note 8: Earthing and Bonding

All the above are published by the IET at www.theiet.org

The “Electricians Guide to Good Electrical Practice” known as a “toolbox guide” is published by the Trade Union AMICUS.

Further information can be found on pages 264 to 267 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

EAW regulations and codes of practice

Using the HSE publication Memorandum of Guidance on the EAW Regulations 1989, consider each section discussed in that publication and make brief notes (bullet points) of each Regulation using the framework below. To start you off, the first few sections have been done for you.

The EAW Regulations 1989. What they are about.

Introduction	• *States when the EAW Regulations came into force in 1989* • *States where their authority comes from, that is the HSW Act* • *EAW Regulations state "principles" of electrical safety which apply to all electrical systems and equipment* • *Acknowledges the authority of the IEE Regulations BS 7671* • *Tells us to be cautious of some codes of practice – they must be drawn up by an Authoritative Body, that is like the IEE.*
Regulation 1	• *Tells us that it came into force on the 1st April 1989.*
Regulation 2	• *Defines what is meant by certain words and phrases used in the EAW Regulations* • *Just like Part 2 of the IEE Regulations BS 7671.*
Regulation 3	• *Defines persons on whom duties are imposed by the EAW Regulations. You should define the following:* Duty holder is .... Reasonably practicable means .... Absolute means ....
Regulation 4	• .... • .... • .... • ....

Regulation 5	• ... ... • ... ... • ... ... • ... ...
Regulation 6	• ... ... • ... ... • ... ... • ... ...
Regulation 7	• ... ... • ... ... • ... ...

Regulation 8	• …… …… • …… …… • …… ……
Regulation 9	• …… …… • …… ……
Regulation 10	• …… …… • …… ……
Regulation 11	• …… …… • …… ……
Regulation 12	• …… …… • …… ……

Regulation 13	• …………………………………… …………………………………… • …………………………………… ……………………………………
Regulation 14	• …………………………………… …………………………………… • …………………………………… ……………………………………
Regulation 15	• …………………………………… …………………………………… • …………………………………… ……………………………………
Regulation 16	• …………………………………… …………………………………… • …………………………………… ……………………………………
Regulation 17 to Regulation 28	**These Regulations apply to mines and quarries only**
Regulation 29	• …………………………………… …………………………………… • …………………………………… …………………………………… • …………………………………… …………………………………… • …………………………………… ……………………………………

Regulation 30	• …………………………………… …………………………………… • …………………………………… ……………………………………
Regulation 31	• …………………………………… …………………………………… • …………………………………… ……………………………………
Regulation 32	• …………………………………… …………………………………… • …………………………………… ……………………………………
Regulation 33	• …………………………………… …………………………………… • …………………………………… ……………………………………
Appendix 1	• …………………………………… ……………………………………
Appendix 2	• …………………………………… ……………………………………
Appendix 3	• …………………………………… ……………………………………

IEE Regulations (BS 7671)

The first edition of the IEE Regulations was issued in 1882 as the Rules and Regulations for the Prevention of Fire Risks Arising from Electric Lighting. In the intervening 126 years there have been many new editions and we are currently using the 17th Edition.

The main reason for incorporating the IEE Wiring Regulations into British Standard 7671 was to create harmonization with European Standards.

On the 31 March 2006, the IEE (Institution of Electrical Engineers) and the IIE (Institution of Incorporated Engineers) joined together to form a new organization, the Institution of Engineering and Technology, the IET. This is now the largest professional engineering society in Europe.

The IEE Wiring Regulations (BS 7671) is the electricians' Bible and provides the authoritative framework for anyone working in the electrotechnical industry.

The IEE Wiring Regulations (BS 7671) are in seven parts and fifteen appendices.

Part 1 – Deals with the scope, object and fundamental principles for safety

- It tells us the type of installation covered by these Regulations.
- It tells us the type of installations requiring supplementary information such as British Standards.
- It tells us the type of installations **NOT** covered by the Regulations.

Part 2 – Deals with definition

- It defines the specific terms used within the Regulations.

Part 3 – Deals with the assessment of general characteristics

- It tells us about the electricity supply and earthing.
- It tells us about external influences, to which an installation will be exposed, such as temperature, water, corrosion.
- It tells us to make an assessment of the frequency and quality of maintenance that an installation can be expected to receive during its intended life.

Part 4 – Deals with protection for safety

- It tells us about the protection measures which must be taken to prevent electric shock and other dangers arising from the use of electricity.
- It tells us about protection against overcurrent.

Part 5 – Deals with the selection and erection of equipment

- It tells us about wiring systems and the current carrying capacity of cables by pointing on to Appendix 4 Tables.
- It tells us about selecting switchgear to give protection against electric shock, overcurrent, isolation and switching.
- It tells us about earthing arrangements and protective conductors.

Part 6 – Deals with inspection and testing

- It tells us about initial verification.
- It tells us about each individual test to be carried out on an installation.
- It tells us about certification and reporting.

Guidance Note 3 – Inspection and testing give explicit details of how to carry out the tests.

Part 7 – Deals with special installations or locations

Some installations need special consideration because of their potentially hazardous location. In these cases additional or replacement regulations are required to provide safety. They are, for example:

- Locations containing a bath tub or shower basin
- Swimming pools
- Hot air saunas
- Construction site installations
- Agricultural and horticultural premises
- Restrictive conductive locations, for example food processing vats
- Marinas and similar locations
- Caravans, motor caravans and caravan parks
- Exhibitions, amusement parks and circuses.

Appendices: There are 15 appendices giving tables and additional information, for example:

Appendix 1 – Gives a list of the British and European Standards.

Appendix 2 – Lists the Statutory Regulations which must be complied with in Great Britain.

Appendix 3 – Gives time current graphs of protective devices.

Appendix 4 – Gives lots of Tables of current carrying capacity and voltage drops of different types of cables and installed conditions.

Appendix 5 – Gives a list of external influences that may apply to electrical equipment such as water, humidity and corrosion.

Appendix 6 – Gives examples of the certification forms to be used when inspecting and testing electrical installations.

Appendix 7 – Gives the new cable colours which came into effect on the 1st April 2004. The new colours used for fixed wiring and flexible cords are now the same as those for the rest of Europe. We are "in harmony" with Europe.

Appendix 15 – Gives very useful and informative diagrams for ring and radial final circuit arrangements.

IEE Regulations (BS 7671)

In Handout 2 we looked at the content of the IEE Regulations (BS 7671). In this Worksheet you will consider those sections of the Regulations which the City & Guilds Syllabus guides us towards. For each section make brief notes (bullet points) and pick out topics relevant to your part of the Electrotechnical industry. The first section has been done for you.

The IEE Regulations (BS 7671) – their impact upon Electrical Installations

Part 5 – Selection and erection of equipment	• *Having designed the electrical installation, the type of equipment, cables and accessories must be chosen.* • *Part 5 deals with the selection of electrical equipment, the materials to be used and the fixing and erection of those materials and equipment to provide compliance with all the Regulations.* • *Equipment and materials must be suitable for the installed environment, for example temperature, presence of water, vibration, corrosion solar radiation.* • *Buried cables must have mechanical protection to prevent penetration by nails and screws.* • *Underground cables must have mechanical protection and be buried at sufficient depth to prevent future damage.* • *MICC cables buried underground should have a PVC sheath to protect the cable from corrosion.* • *Cables installed in timber joists should be at least 50 mm from the top and bottom or have a metal plate installed over them.* • *Orange shall be used as the colour to distinguish electrical services from other pipelines or services.* • *Any equipment used must have a relevant BS or BSEN Standard which confirms that it will comply with the use for which it was intended.* • *Warning notices which comply with BS 951 must be fitted to earthing and bonding connections.* • *The installed wiring system must not reduce the fire safety of the general building structure.*

Chapter 53 **Isolation and switching**	
Part 6 – **Inspection and testing**	
Chapter 42 **Protection against fire**	

Chapter 41 Protection against electric shock	....
Chapter 43 Protection against overcurrent	....
Part 7 – Special locations	....

Special locations

All electrical installations must be suitable for the installed conditions and intended use. However, some electrical installations require special consideration because of their potentially hazardous location.

State the special arrangements that need to be considered for an electrical installation in the following locations. The first one has been done for you.

Location – Bathrooms

Particular hazard:

- *electric shock when body resistance is lowered by being wet.*

Made safe by:

- *providing both overload and 30 mA RCD protection to both lighting and power circuits*
- *locating the bath or shower room in a building with protective equipotential bonding in place*
- *bonding all metalwork in bathrooms may also be required*
- *bathroom is divided into zones and electrical equipment in zones is restricted*
- *zone O is most dangerous and therefore normally no electrical equipment is allowed.*

Location – External installations (e.g. car parks, marinas)

Particular hazard:

- ....

Made safe by:

- ....

  ....
- ....

  ....
- ....

  ....
- ....

  ....

Further information can be found in chapters 13 and 14 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Location – Flammable/explosive situations

Particular hazard:
- ....

Made safe by:
- ....
....
- ....
....
- ....
....
- ....
....

Location – Temporary and construction sites

Particular hazard:
- ....

Made safe by:
- ....
....
- ....
....
- ....
....
- ....
....

Further information can be found on pages 270 to 273 and 324 to 326 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Location – Agricultural and horticultural installations

Particular hazards:

- ....
- ....
- ....
- ....
- ....

Made safe by:

- ....
- ....
- ....
- ....

Further information can be found on pages 326 to 327 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

On-site documentation

Good communication is about transferring information from one person to another. How many hours or days did you spend on a particular job last week? How does your boss know how many hours of work you put in on that job so that he can charge the customer for your time? How much material did you use on that job last week? How does your boss know how much material you used, so that a charge to the customer can be made for it?

Most electrical companies have standard forms which help them to keep track of time put in and materials used.

Use your experiences at work to describe the use of the following standard forms. Why are they used and what information do they give?

Time Sheets ....

....

....

Job Sheets ....

....

....

Day Work Sheets ....

....

....

Delivery Records or Notes ....

....

....

Reports ....

....

....

Further information can be found on pages 184 to 188 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Choosing a wiring system

In Worksheet 2 of this Unit we looked at Part 5 of the IEE Regulations dealing with the selection and erection of electrical equipment. Part 5 tells us that electrical equipment and materials must be chosen so that they are suitable for the installed environment, taking into account temperature and the possible presence of water, corrosion, vibration or solar radiation.

For the situations given below, state the wiring system you would choose, that is, the type of wiring enclosures and electrical equipment. The first situation has been completed for you.

Situation 1. Hotel car park floodlights – subject to wind and rain.

Wiring system *This is an external installation and I would therefore choose either MICC cables or SWA cables. I would ensure that the luminaires were of a design suited to external use and that all connections between the cables and luminaires were suitably waterproof.*

Situation 2. School or college boiler house – high ambient temperature.

Wiring system

....

....

....

Situation 3. Fork lift truck battery charging room – possible corrosive substances.

Wiring system

....

....

....

Situation 4. Commercial greenhouse – high UV solar radiation.

Wiring system

. . . .

. . . .

. . . .

Situation 5. Factory process plant – subjected to mechanical stresses and vibration.

Wiring system

. . . .

. . . .

. . . .

Situation 6. Milking parlour on farm – possible damage by animals (cows and vermin).

Wiring system

. . . .

. . . .

. . . .

Situation 7. Church, new internal lighting – the electrical installation must not detract from the beauty of the Church architecture (aesthetic considerations).

Wiring system

. . . .

. . . .

. . . .

Further information can be found on pages 128 to 129 and Chapters 13 and 14 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Electrical components used in electrotechnical systems

State the function of each of the following components or circuits used in an electrotechnical system. That is, what does each of these things do. The first two have been answered for you.

1. Switches	*a mechanical device capable of making, carrying and breaking an electric current (see BS 7671 Section 537).*
2. Lamps and luminaires	*a lamp is a device for converting electrical energy into light energy. There are many types of lamp, GLS, fluorescent, tungsten halogen. A luminaire is equipment which supports a lamp and distributes or filters the light from the lamp.*
3. Terminals and connections	....
4. Ring and radial circuits & sockets	....
5. Cooking and water heating circuits	....
6. Electric motors	....

7. Industrial installations	....
8. Controls such as meters, switchgear, thermostats, timers, detectors	....
9. Security system relays, detectors, controls, maintained system, non-maintained system	....
10. Data/communication systems, cables and components	....

Further information can be found on pages 291 to 296, 306 to 312 and 332 to 338 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Secure electrical isolation

Use the bullet points below to give a step by step account of how you would safely isolate and lock off live electrical circuits before beginning work on those circuits.

-
-
-
-
-
-

Name the type of "voltage indicator" that you would use at work.

Voltage indicator type ....

....

What does the HSE Guidance Note 38 tell us about test leads?

Test leads must ....

....

What is a "Voltage Proving Unit"?

A voltage proving unit is ....

....

Further information can be found on page xxx of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Measuring and marking out

1.	Briefly describe what you would use the following equipment for when measuring and marking out. The first question has been answered for you.	
a.	**Set square**	*a tool marking right angles on, for example, trunking, so that the trunking can be cut square.*
b.	**Scribes**	....
c.	**Gauges**	....
d.	**Spirit level**	....
e.	**Plumb bob**	....
f.	**Chalk line**	....
g.	**Steel ruler**	....
h.	**Steel tape measure**	....
i.	**Laser level**	....

2. Briefly describe, with a sketch if that helps, how you would mark out and fix a steel trunking run down one wall of a very long office. The building is still being constructed, the floors are not yet finished and the suspended ceiling is not yet in place. The trunking will be above the finished suspended ceiling and facilitate conduit drops down to sockets and up and across the ceiling to lighting points. The suspended ceiling will be 2600 mm from the finished floor level. The present floor to ceiling height is 3700 mm. The walls are constructed of thermalite block.

Fixing and installing equipment

Use a sketch to describe how the **fixing devices** named below are used to secure electrical equipment to different surfaces – **"What does each look like?"** – **"How do they work?"** and **"Where would they be used?"**.

1. **Wood screws**
2. **Spring toggles**
3. **Girder clips**
4. **Crampets or Pipe hooks**
5. **Masonry bolts or Rawlbolts**

Further information can be found on pages 319 to 324 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Tools and equipment used for electrical installations

Use a sketch to describe how the **tools** named below are used for installing electrical equipment. **"What does each look like?" – "How do they Work?"** and **"Where would they be used?"**.

1. Cable cutters
2. Wire strippers
3. Knives
4. Saws and drills
5. Files and reemers

6. Spanners and wrenches	
7. Bending and forming (shaping) conduit, tray and trunking	
8. Adhesives	

Further information can be found on pages 142 to 146 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Correct disposal of waste material

The Controlled Waste Regulations 1998 tell us that we have “a **‘Duty of Care’** to handle, recover and dispose of waste responsibly”.

The Environmental Protection (Duty of Care) Regulations 1991 tell us that any business has a duty to ensure that any waste produced is handled safely and in accordance with the law.

New Hazardous Waste Regulations were introduced in 2005 and under these regulations electric lamps and tubes are classified as “hazardous waste.”

Your company is responsible for the waste that it produces even after handing it over to another party such as a Skip Hire company. If such a third party mishandles your waste or disposes of it irresponsibly then it is your company who is responsible, not the Skip Hire company. The duty of care under the new Regulations has no “time limit” and extends until the waste has either been finally and properly disposed of or fully recovered.

To comply with these Regulations the main contractor on site must:

- Make sure waste is transferred only to “authorized” companies.
- Make sure that the waste being taken is accompanied by the proper paperwork called “waste transfer notes”.
- Label waste skips and waste containers so that it is clear to everyone, for example main contractors and sub-contractors, what type of waste is going into which skip.
- Minimize the waste that you produce and do not leave it behind when a job is completed for someone else to clear away. Remember there is no time limit on the Duty of Care for waste materials.

Occupiers of domestic properties are exempt from the Duty of Care for household waste.

Further information can be found on pages 172 to 175 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Correct disposal of waste

Electrotechnical companies produce very little waste material and even smaller amounts of “special waste”. Most electrical contractors deal with waste by buying in the expertise and building in these costs to the total cost of a contract. However, this method still requires individuals to sort any waste responsibly by placing it in the appropriate skip or container.

1. Describe what we mean by “special waste” and how special waste must be disposed of.

....

....

....

....

....

....

2. You are coming to the end of a large contract and while your line manager is testing and commissioning the installation, you and another apprentice are asked to pack everything away and clear the site of any waste material produced by your company. State briefly what you would do with each of the following materials and equipment.

Lots of off-cut lengths of steel conduit and trunking ....

....

....

....

....

....

Lots of part rolls of cable and part boxes of accessories	....
Lots of old 1200 and 1800 mm fluorescent fittings made of sheet steel	....
Lots of old 1200 and 1800 mm fluorescent tubes	....
Lots of cardboard boxes in which the new modular fluorescent fittings were packed	....
Five stepladders and one short extension ladder	....

Note: more than one answer given may be correct.

1. **The EAW Regulations are:**
   a. Non-statutory Regulations ☐
   b. Statutory Regulations ☐
   c. a code of practice ☐
   d. a British Standard. ☐

2. **The IEE Regulations are:**
   a. Non-statutory Regulations ☐
   b. Statutory Regulations ☐
   c. a code of practice ☐
   d. a British Standard. ☐

3. **A British Standard having a BS number is a:**
   a. Statutory Regulation ☐
   b. Non-statutory Regulation ☐
   c. British compliant Standard ☐
   d. European harmonized Standard. ☐

4. **A British Standard having a BS EN number is a:**
   a. Statutory Regulation ☐
   b. Non-statutory Regulation ☐
   c. British compliant Standard ☐
   d. European harmonized Standard. ☐

5. **Part 5 of the IEE Regulations deals with:**
   a. protection for safety ☐
   b. selection and erection of equipment ☐
   c. special installations ☐
   d. Inspection and testing. ☐

6. **Part 6 of the IEE Regulations deals with:**
   a. protection for safety ☐
   b. selection and erection of equipment ☐
   c. special installations ☐
   d. Inspection and testing. ☐

7. **Part 7 of the IEE Regulations deals with:**
   a. protection for safety ☐
   b. selection and erection of equipment ☐
   c. special installations ☐
   d. Inspection and testing. ☐

8. **A time sheet shows:**
   a. a record of goods delivered by a supplier ☐
   b. a record of work done which is outside the original contract ☐
   c. information about work to be done, usually a small job ☐
   d. the actual time spent working on a particular job or site. ☐

9. A job sheet or job card shows:

a. a record of goods delivered by a supplier ☐
b. a record of work done which is outside the original contract ☐
c. information about work to be done, usually a small job ☐
d. the actual time spent working on a particular job or site. ☐

10. A day work sheet shows:

a. a record of goods delivered by a supplier ☐
b. a record of work done which is outside the original contract ☐
c. information about work to be done, usually a small job ☐
d. the actual time spent working on a particular job or site. ☐

11. A delivery note shows:

a. a record of goods delivered by a supplier ☐
b. a record of work done which is outside the original contract ☐
c. information about work to be done, usually a small job ☐
d. the actual time spent working on a particular job or site. ☐

12. The HSW Act places the responsibility for safety at work on:

a. the employer ☐
b. the employee ☐
c. both the employer and the employee ☐
d. the main contractor. ☐

13. Under the HSW Act an Employer must ensure that:

a. the working conditions are appropriate and safety equipment is provided ☐
b. employees take reasonable care of themselves and others as a result of work activities ☐
c. employees co-operate with an employer and do not interfere with or misuse safety equipment ☐
d. plant and equipment is properly maintained. ☐

14. Under the HSW Act Employees must ensure that:

a. the working conditions are appropriate and safety equipment is provided ☐
b. they take reasonable care of themselves and others as a result of work activities ☐
c. they co-operate with an employer and do not interfere with or misuse safety equipment ☐
d. plant and equipment is properly maintained. ☐

15. Equipment which displays the BSI kite mark:

a. is guaranteed to perform efficiently ☐
b. has been produced under a system of supervision and control by a manufacturer holding a licence ☐
c. will reduce the risk of an electric shock under fault conditions to anyone using the product ☐
d. carries a guarantee of the product's electrical, mechanical and thermal safety. ☐

16. Equipment which carries the BSI safety mark:
a. is guaranteed to perform efficiently ☐
b. has been produced under a system of supervision and control by a manufacturer holding a licence ☐
c. will reduce the risk of an electric shock under fault conditions to anyone using the product ☐
d. carries a guarantee of the product's electrical, mechanical and thermal safety. ☐

17. The CE mark:
a. is a quality symbol ☐
b. is an indication that the product meets the legal safety requirements of the European Commission ☐
c. guarantees the product's efficiency ☐
d. will reduce the risk of electric shock under fault conditions to anyone using the product. ☐

18. What action is necessary to produce a "secure electrical isolation"?
a. isolate the supply and observe that the voltage indicator reads zero ☐
b. first connect a test device such as a voltage indicator to the supply ☐
c. larger pieces of equipment may require isolating at a local isolator switch ☐
d. the isolated supply must be locked off or secured with a small padlock. ☐

19. A voltage proving unit:
a. is used for transmitting data along optical fibre cables ☐
b. provides a secure computer supply ☐
c. shows a voltage indicator to be working correctly ☐
d. tests for the presence of a mains voltage supply. ☐

20. A Plump-bob:
a. is used for marking right angles ☐
b. tests for level and horizontal ☐
c. puts a straight and true chalk mark on a surface ☐
d. is a weight on a piece of string used to check and find verticals. ☐

21. A spirit level:
a. is used for marking right angles ☐
b. tests for level and horizontal ☐
c. puts a straight and true chalk mark on a surface ☐
d. is a weight on a piece of string used to check and find verticals. ☐

22. A chalk line or chalked string:
a. is used for marking right angles ☐
b. tests for level and horizontal ☐
c. puts a straight and true chalk mark on a surface ☐
d. is a weight on a piece of string used to check and find vertical. ☐

23. A set square:
a. is used for marking right angles ☐
b. tests for level and horizontal ☐
c. puts a straight and true chalk mark on a surface ☐
d. is a weight on a piece of siring used to check and find vertical. ☐

24. **Wood screws would be used to secure:**
    - a. an accessory to the surface of a plaster-board wall ☐
    - b. a conduit to a wall which is to be plastered over ☐
    - c. an accessory to the surface of a pre-drilled brick wall filled with a plastic plug ☐
    - d. a heavy object to a pre-drilled concrete surface. ☐

25. **Masonry bolts would be used to secure:**
    - a. an accessory to the surface of a plaster-board wall ☐
    - b. a conduit to a wall which is to be plastered over ☐
    - c. an accessory to the surface of a pre-drilled brick wall filled with a plastic plug ☐
    - d. a heavy object to a pre-drilled concrete surface. ☐

26. **Crampets would be used to secure:**
    - a. an accessory to the surface of a plaster-board wall ☐
    - b. a conduit to a wall which is to be plastered over ☐
    - c. an accessory to the surface of a pre-drilled brick wall filled with a plastic plug ☐
    - d. a heavy object to a pre-drilled concrete surface. ☐

27. **Spring toggles would be used to secure:**
    - a. an accessory to the surface of a plaster-board wall ☐
    - b. a conduit to a wall which is to be plastered over ☐
    - c. an accessory to the surface of a pre-drilled brick wall filled with a plastic plug ☐
    - d. a heavy object to a pre-drilled concrete surface. ☐

28. **To remove the burrs from the cut end of a conduit would require a tool called a:**
    - a. hacksaw ☐
    - b. pipe vice ☐
    - c. reemer ☐
    - d. pipe spring. ☐

29. **One advantage of a steel conduit installation, compared with a PVC conduit installation is that it:**
    - a. may be easily rewired ☐
    - b. may be installed more quickly ☐
    - c. offers greater mechanical protection ☐
    - d. may hold more conductors for a given conduit size. ☐

30. **The earth continuity of a metallic conduit installation will be improved if:**
    - a. black enamel conduit is replaced by galvanized conduit ☐
    - b. the installation is painted with galvanized paint ☐
    - c. the installation is painted with bright orange paint ☐
    - d. all connections are made tight and secure during installation. ☐

31. **The earth continuity of a metallic trunking installation may be improved if:**
    - a. copper earth straps are fitted across all joints ☐
    - b. galvanized trunking is used ☐
    - c. all joints are painted with galvanized paint ☐
    - d. a space factor of 45% is not exceeded. ☐

32. **An industrial installation of PVC/SWA cables laid on cable tray offers the advantage over other types of installation of:**
    - a. greater mechanical protection ☐
    - b. greater flexibility in response to changing requirements ☐
    - c. higher resistance to corrosion in an industrial atmosphere ☐
    - d. flameproof installation suitable for hazardous areas. ☐

33. The cables which can best withstand high temperatures are:
a. MI cables ☐
b. PVC cables with asbestos sleeves ☐
c. PVC/SWA cables ☐
d. PVC cables in galvanized conduit. ☐

34. An example of "special waste" is:
a. sheets of asbestos ☐
b. old fibre-glass roof insulation ☐
c. old fluorescent tubes ☐
d. part coils of PVC insulated cables. ☐

35. Special waste must be disposed of:
a. in the general site skips ☐
b. in the general site skip by someone designated to have "a duty of care" ☐
c. at the "household waste" re-cycling centre ☐
d. by an "authorized" company using a system of "waste transfer notes". ☐

36. The test required by the Regulations to ascertain that the circuit protective conductor is correctly connected is:
a. continuity of ring final circuit conductors ☐
b. continuity of protective conductors ☐
c. earth electrode resistance ☐
d. protection by electrical separation. ☐

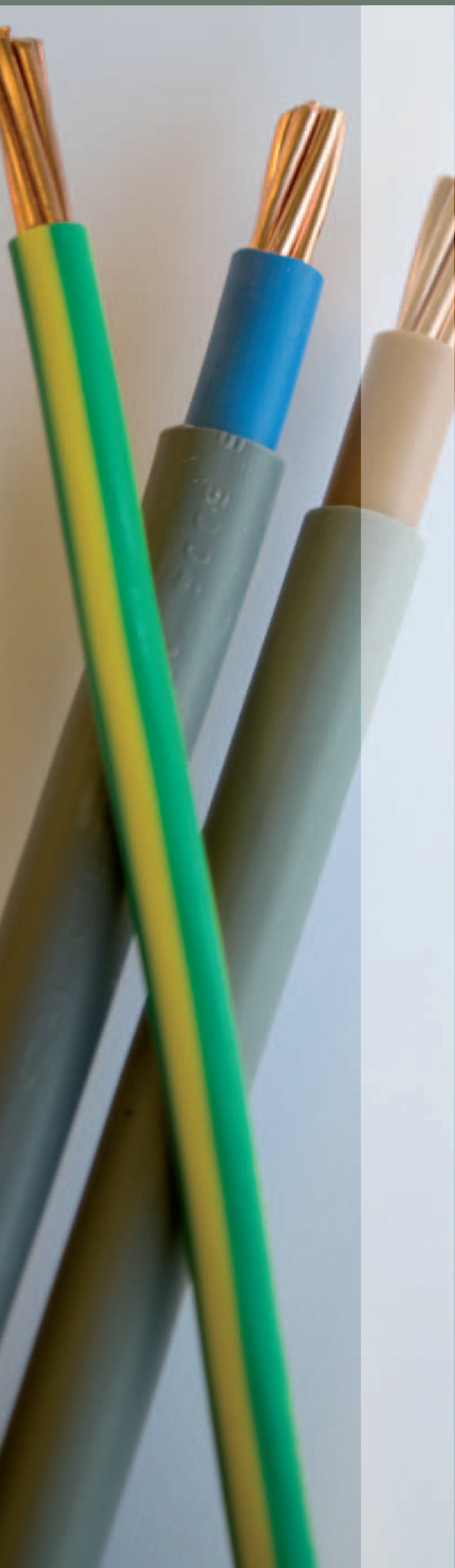
37. A visual inspection of a new installation must be carried out:
a. during the erection period ☐
b. during testing upon completion ☐
c. after testing upon completion ☐
d. before testing upon completion. ☐

38. One objective of the polarity test is to verify that:
a. lampholders are correctly earthed ☐
b. final circuits are correctly fused ☐
c. the circuit protective conductor (CPC) is continuous throughout the installation ☐
d. the protective devices are connected in the live conductor. ☐

39. When testing a 230V installation an insulation resistance tester must supply a voltage of:
a. less than 50V ☐
b. 500V ☐
c. less than 500V ☐
d. greater than twice the supply voltage but less than 1000V ☐

40. The value of a satisfactory insulation resistance test on each final circuit of a 230V installation must be:
a. less than 1 Ω ☐
b. less than 0.5 MΩ ☐
c. not less than 0.5 MΩ ☐
d. not less than 1 MΩ. ☐

Answers to Worksheets 1 to 12



Worksheet 1

You will require copies of the *Memorandum of Guidance on the EAW Regulations 1989* for this task.

1 and 2 – Regulations 1 and 2 have been completed.

3. "Duty holder" – is the person who has a duty to comply with these Regulations.

"Reasonably practicable" – means the duty holder may assess the magnitude of the risk against the cost of reducing the risk. The duty holder may have to prove that he or she took all steps to reduce the risk as far as is reasonably practicable in a court of law.

"Absolute" – must be done regardless of cost.

4. First part deals with construction of electrical systems – equipment must be suitable for its intended use and constructed so as to make it safe. Second part deals with the maintenance of electrical systems, regular inspections and records, so that it remains safe. Third part deals with ensuring safe work activities – making dead – isolation – lock off. Fourth part deals with protective equipment – insulated tools – test probes – must be suitable for use, well maintained and properly used.

5. No electrical equipment shall be put to use where its strength and capability may be exceeded and give rise to danger. For example, switchgear must be capable of handling fault currents as well as normal load currents, earthing conductors must be adequately rated to survive beyond fault clearance times. Electrical equipment must be used within the manufacturer's rating and in accordance with any instructions.

6. Deals with the installed conditions – you must consider when selecting and installing electrical equipment, the hazards to which it might be exposed, not just at the present but what you could reasonably expect may be the situation in the future "as far as is reasonably practicable". These include mechanical damage, effects of weather, temperature and pressure, wet, dirty, dusty and corrosive conditions and any flammable or explosive substances. Cross-reference here to Chapter 52 of IEE Regulations BS 7671.

7. All conductors in a system which may give rise to danger must be either insulated or placed out of reach. Cross-reference to Basic Protection definitions in Part 2 and 411, 416 and 417 of the IEE Regulations.

8. Deals with the requirements for earthing and bonding to reduce the risk of electric shock when a conductor, other than a circuit conductor, becomes live under fault conditions. Cross-reference here to Chapter 54 and Fault Protection definitions in Part 2 and 411 of the IEE Regulations BS 7671 and the importance of protective equipotential bonding.

9. States that the neutral conductor must not have a switch or fuse placed in it. The only exception being that where a switch is placed in the neutral conductor it must be interlocked to break the phase conductors at the same time.

10. Requires all joints and connections in the electrical system to be mechanically and electrically suitable for its use. Cross-reference here to Chapter 52 Section 526 of the IEE Regulations BS 7671.

11. Efficient means, suitably located – shall be provided for protection against excess current so as to prevent danger. Cross-reference here to Chapter 43 of the IEE Regulations BS 7671.

12. This Regulation deals with the need for switching off and isolation of electrical equipment from every source of supply in such a way that it cannot be reconnected accidentally. Cross-reference here to Regulation 4(3) of EAW Regulations and Chapter 53 and particularly 537 of the IEE Regulations BS 7671.

13. This Regulation deals with the need to prevent isolated equipment which has been made dead, becoming "live" while work is continuing. For example, it may be necessary to "lock off" an isolator or remove the fuses and hold them in "safe keeping" to provide a secure isolation. A "safe isolation procedure" or "written permit to work scheme" may be required by this Regulation dependent upon the industrial procedure or process.

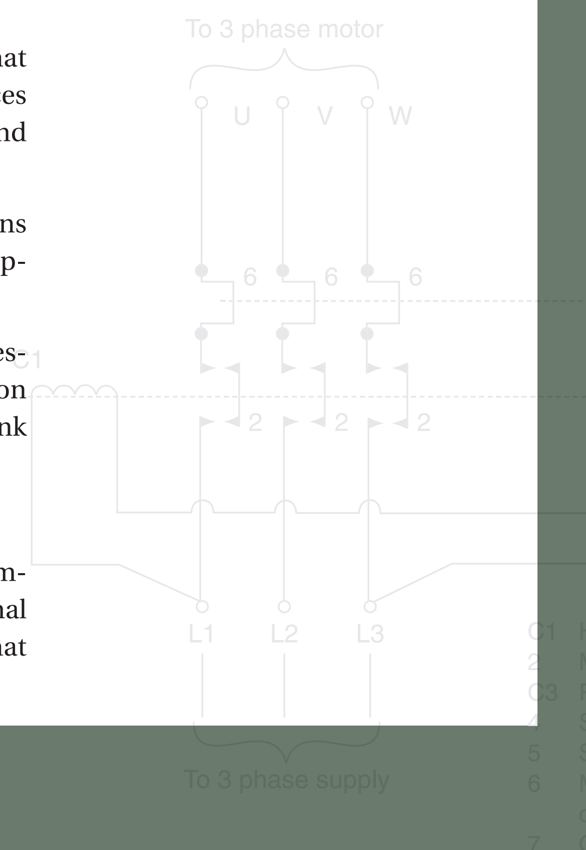
14. When working on or near live conductors it is always preferable that they should first of all be made dead. Only in exceptional circumstances would this be allowed and staff would need to be specially trained and competent to work on or near live equipment safely.

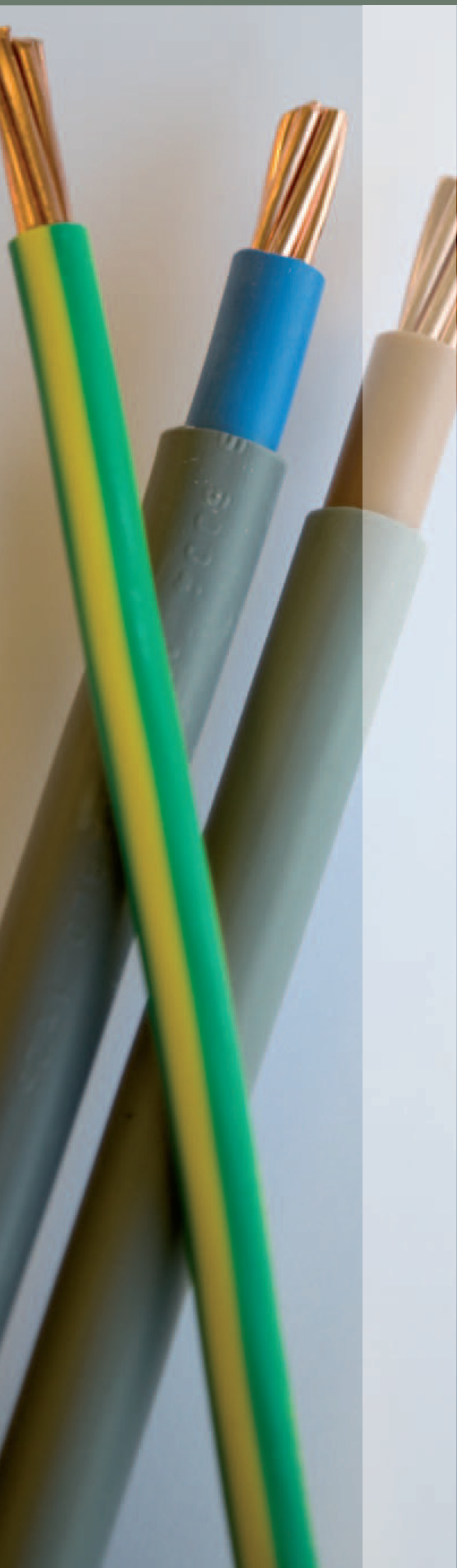
15. To prevent injury occurring, adequate working space, adequate means of access and adequate lighting must be provided at all electrical equipment on which work is being done.

16. No-one shall be engaged in a work activity unless they have the necessary technical competence and experience or are under close supervision by someone who is competent so as to prevent danger and injury. Link here to IEE Regulation 134.1.1.

17 to 28 inclusive apply to mines and quarries only.

29. This is known as the "defence Regulation". If the duty holder commits an offence under the EAW Regulations, the HSE will bring criminal proceedings against them. The duty holder's only defence is to prove that





they took all reasonable steps and exercised all due diligence to avoid committing that offence. Work which meets the requirements of the IEE Regulations BS 7671 will achieve compliance with the EAW Regulations. However, in these circumstances the duty holder would do well to be supported by his "friends", the AMICUS team of lawyers.

30. The duty holder may apply for exemption from these Regulations. This would only be granted in "very exceptional" circumstance, and provided that it did not prejudice the health and safety of any persons.

31. This tells us that, in general, these Regulations also apply to work outside Great Britain.

32. This tells us that these Regulations **do not** apply to sea-going ships and aircraft or hovercraft moving under their own power.

33. This identifies changes and modifications to the Regulations since they were brought in.

Appendix 1. A list of HSE publications. HSE contact numbers are given in Appendix B of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Appendix 2. A list of other British Standards and codes of practice.

Appendix 3. An historical comment on working space and access.

Worksheet 2

The syllabus tells us to state how sections/topics in BS 7671 impact upon electrical installations. Answers are, therefore, at the discretion of individual lecturers meeting the needs of their own students.

Part 5 has been completed to give the student some guidance.

Chapter 53 – Perhaps you might wish to begin by identifying the four types of switching and give examples of each. You might also like to include Regulations 132.12 and 132.15 adequate and safe means of access. There is a similar requirement in the EAW Regulations 12, 13 and 15.

Part 6 of the Regulations gives "what" must be tested, "when" it must be tested, and "how" it must be tested. Answers are, therefore, at the lecturer's discretion.

Chapter 42 – Fire safety – The installed wiring system must not reduce the fire safety of the general building structure – 527.1.2.

The heat generated by electrical equipment must not cause a fire hazard to adjacent material – 421.1.

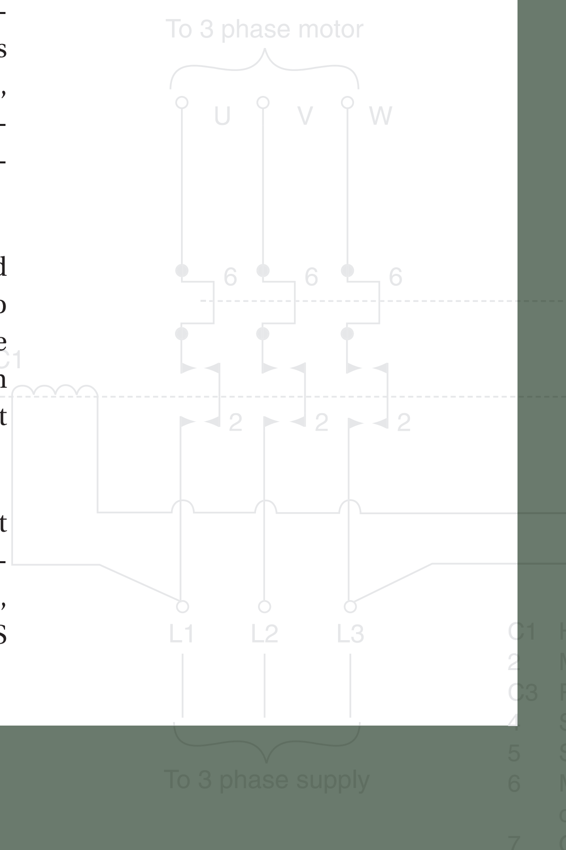
The opening remaining in the building structure following the installation of a wiring system must be made good to prevent the spread of fire – 527.2.1.

Trucking or ducting must be internally sealed with fire barriers – 527.2.4.

Approved document B of the Building Regulations – Fire safety – is also relevant here. Section 10.2.2, Spread of fire – requires precautions to be taken to inhibit the spread of fire within a building. “When carrying out electrical installations, the installer must not degrade the design features intended to limit the spread of fire or limit the propagation of smoke and fumes”. “Luminaires penetrating ceilings may require fitting with fire resistant hoods”.

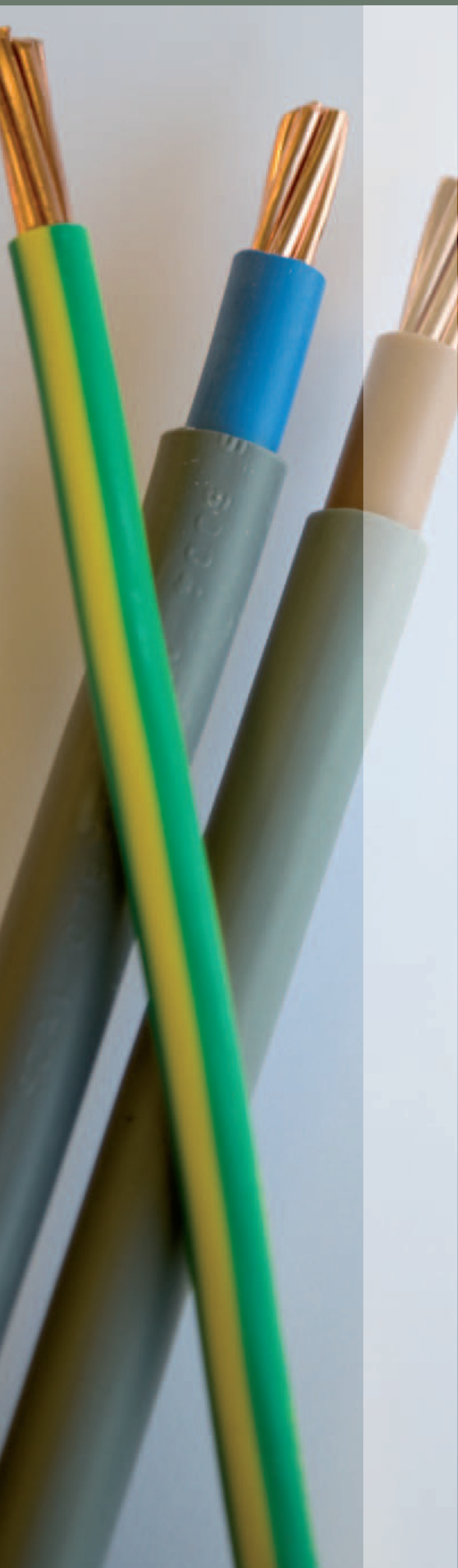
Chapter 41 – Shock protection. The provision of protection from electric shock in an installation is fundamental to the whole concept of the safe use of electricity in buildings. A person can receive a shock in two ways, firstly by coming into contact with live parts (direct contact) and secondly, by coming into contact with metallic parts which have become live because of a fault (indirect contact). Basic protection gives protection against direct contact and fault protection gives protection against indirect contact.

SELV – Separated Extra Low Voltage (i.e. separated from earth) gives both basic and fault protection. Basic protection is achieved by (1) insulating live parts, (2) putting live parts in enclosures or behind barriers, (3) placing live parts behind obstacles, (4) placing live parts out of reach. Perhaps here discuss how this is achieved and give typical examples. For example, where protection by barriers or enclosures is used, then the degree of protection must be at least IP2X, which is the Index of Protection for the standard finger – 80 mm long and 12 mm in diameter.



Fault protection is achieved by protective equipotential bonding and automatic disconnection of the supply. This requires all metalwork to be bonded, the earth fault loop impedance to be low and the protective device (fuse or MCB) to be chosen so that it will remove a voltage between exposed and extraneous conductive parts very quickly when a fault occurs.

Chapter 43 – Overcurrent protection – The Regulations tell us at 430.3 that a protective device shall be provided to break any overcurrent in the circuit conductors before such a current could cause a danger. Overcurrent, overload current and fault current are defined in Part 2 Definitions of BS 7671 and might make a useful contribution to this section.



List the devices providing overcurrent protection as general purpose fuse to BS 88, a fuse to BS 1361 or circuit breaker to BSEN 60898.

Identify the position of protective devices in an installation as "at a point where a reduction occurs in the value of current carrying capacity of the conductors due to a change in cross-sectional area" IEE Regulation 433.2.

Part 7 – Special locations – All electrical installations must be suitable for the installed conditions and intended use (fitness for their purpose) but some electrical installations require special consideration because of their potentially hazardous location. Part 7 of BS 7671: 2008 identifies 14 special installations or locations which require additional or replacement regulations to provide greater safety.

Lecturers may want to direct students to the installations or locations which are relevant to their students' needs. See also Worksheet 3 which look at 5 common special locations.

Worksheet 3

Answers at Lecturer's discretion but:

Bathroom – done. **External Installation hazard** – wind rain, vandalism – corrosive elements and presence of water in marinas – made safe by using waterproof, vandal proof fittings, by using suitable cables SWA, MICC, galvanized conduit, waterproof and RCD protection for socket outlets and by fixing out of reach.

Flammable, explosive hazard is explosion by ignition of flammable liquid – made safe by use of flameproof fittings marked Ex, use of flameproof cables such as MICC, SWA or solid drawn conduit. Use of longer flameproof glands for all terminations.

Construction site hazard is electric shock as a result of the wet, damp and temporary nature of the electrical supply – made safe by using low voltage equipment, using battery powered hand tools, using industrial standard plugs and sockets to BS EN 60309, using RCD protected supplies.

Agricultural and horticultural hazard is electric shock to humans and animals as a result of dampness, corrosion and damage caused by animals and vermin – made safe by using RCD protected supplies to all socket outlets, using waterproof sockets and switches, using additional protective equipotential bonding, cables used must be buried deep or suspended high and cables must withstand UV solar radiation.

Worksheet 4

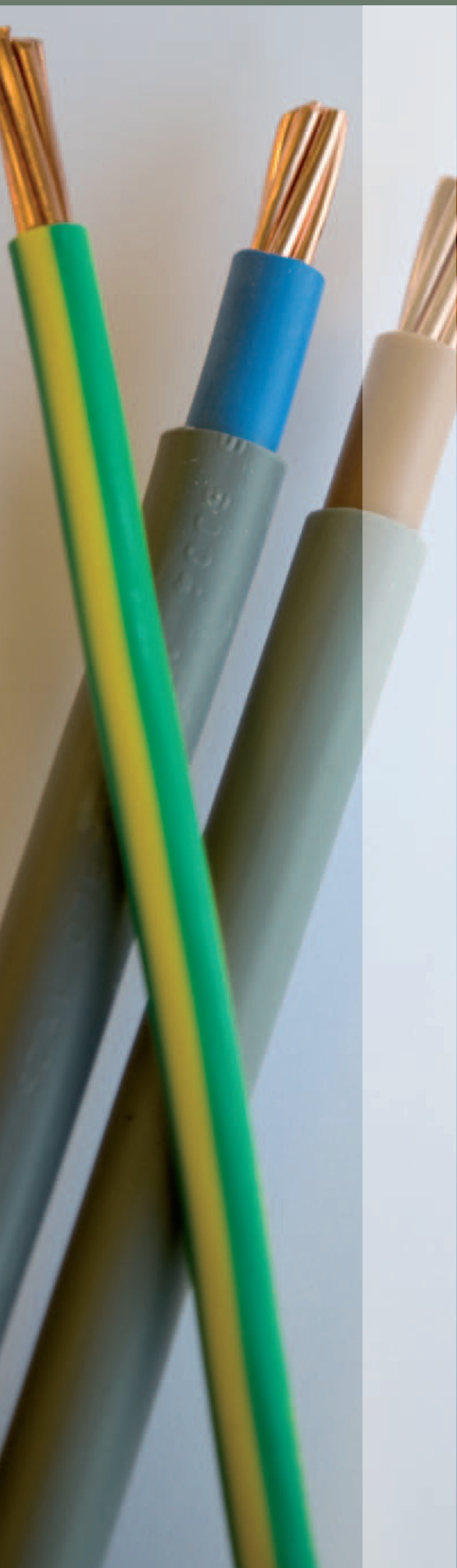
This topic appears again in Unit 4 Outcome 2 but was originally done in Core Unit 3 Outcome 2. Lecturers may choose to use this worksheet as a revision exercise. Answers at Lecturer's discretion but definitions can be found on pages 184 to 188 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Worksheet 5

Answers at Lecturer's discretion but (1) done; (2) MICC or FP 200; (3) MICC, FP 200 or PVC conduit; (4) MICC, FP 200 or PVC conduit with expansion considerations; (5) metal conduit, terminations to vibrating machinery in flexible conduit; (6) galvanized conduit, waterproof fittings; (7) MICC or FP 200.

Worksheet 6

Answers at Lecturer's discretion but; (1) and (2) are done; (3) a means of providing the mechanical connection of electrical conductors; (4) two methods of connecting 13 A sockets to a source of supply. **A ring circuit** is a final circuit arranged in the form of a ring and connected to a single point of supply. **A radial circuit** is a final circuit connected to a separate way in a distribution board and radiating out to permanently connected equipment or socket outlets but does not return to the point of supply; (5) these are separate radial circuits connecting permanently connected equipment which converts electrical energy into heat energy for the purpose of cooking and heating; (6) an electromagnetic device converting electrical energy into motive energy for machine drives. Motors are found in industry, in domestic appliances, computer printers and disc drives; (7) robustly installed electrical systems to control industrial processes; (8) **Meters** – an instrument for measuring the passage of electricity. **Switchgear** – an assembly of main and auxiliary switching apparatus to control an electrical installation. **Thermostat** – provides an automatic control of electricity with an increase or decrease in temperature. **Detectors** – when used in process control, a detector is an electrical or mechanical device which produces an electrical signal in response to the detector's environment, for example a transducer; (9) a **relay** is an electromagnetic device used to activate an electric circuit. In security systems **a detector** is an electrical switch activated by a moving body or intruder, for example proximity switch, PIR detector. **Control** or control panel is at the heart of any security system permitting entry and exit delays and keypad activation. A **maintained** system is continuously active using the mains supply when available and switching to battery supply during mains failure, for example emergency lighting. A **non-maintained** system is only activated in the event of a mains failure, for example standby lighting and emergency lighting; (10) Electrical units which separately or assembled in systems, accumulate, process and store data. Networks based on digital



technology may use copper cables or optical fibre cables. All physical components are called “hardware”, such as printers, disc drives and VDUs. The programmes which run on the system are called “software”.

Worksheet 7

Answers at Lecturer’s discretion.

Secure isolation is described on pages 169 to 172 of *Basic Electrical Installation Work* 5th Edition ISBN 9780750687515.

Voltage indicator type must be an “approved” type.

GN 38 – must incorporate finger barriers, fuse and robust well insulated leads.

Proving unit – device for proving correct operation of test device.

Worksheet 8

1. Answers at Lecturer’s discretion.
2. Answers at Lecturer’s discretion – this Worksheet provides an activity for Outcome 4.5 and 4.6 of the City & Guilds 2330 Syllabus. We are looking for a description of measuring and marking out a long straight level run of trunking above the suspended ceiling but far enough away from the building’s ceiling to facilitate a right angled conduit bend to the lighting positions.

Worksheet 9

Answers at Lecturer’s discretion but this Worksheet provides an activity for Outcome 4.7 of the City & Guilds 2330 Syllabus. Sketches and descriptions can be found on pages 319 to 324 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

Worksheet 10

Answers at Lecturer’s discretion but this Worksheet provides an activity for 4.11 of the City & Guilds 2330 Syllabus. Sketches and descriptions can be found on pages 142 to 146 of *Basic Electrical Installation Work* 5th Edition. At 7 we bend and shape conduit and tray from the straight length but trunking requires manufactured or site made bends. Adhesives are becoming more popular for securing plastic conduit and mini-trunking.

Worksheet 11

1. Answers at Lecturer's discretion but this Worksheet provides an activity for Outcome 4.14 of City & Guilds 2330 Syllabus. Special waste is waste that is potentially hazardous, for example asbestos, fluorescent tubes. Disposal by specialist company. File waste transfer notes safely at Head Office.

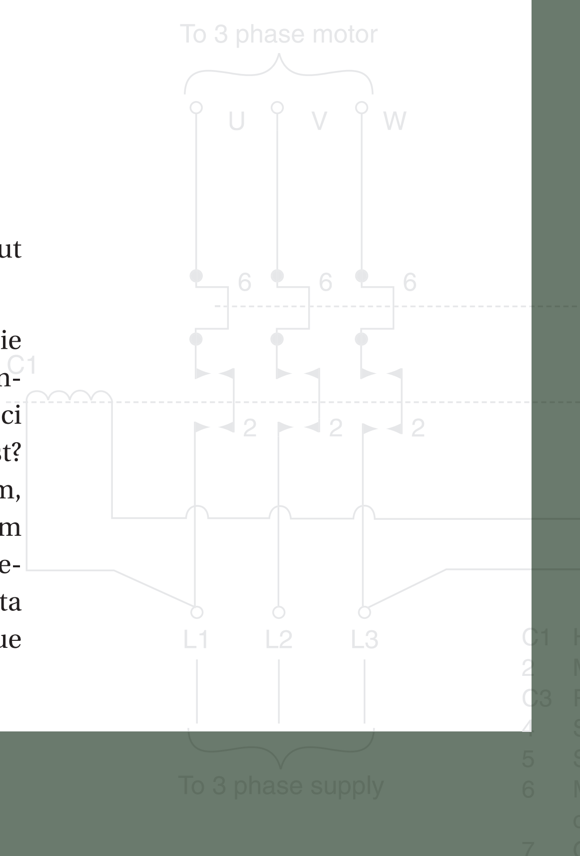
2. Answers at Lecturer's discretion but cut pieces of trunking and conduit, cardboard plus old fluorescent fittings into the general disposal skip. Fluorescent tubes should be recycled by a specialist company probably arranged through the electrical wholesaler. Apprentices should not make this decision themselves but seek guidance from their supervisor. Part rolls of cable, accessories, stepladders and extension ladders to be transported back to the company stores.

Worksheet 12 (MC questions)

1 = b	**11 = a**	**21 = b**	**31 = a**
2 = a, c and d	**12 = c**	**22 = c**	**32 = b**
3 = c	**13 = a and d**	**23 = a**	**33 = a**
4 = d	**14 = b and c**	**24 = c**	**34 = a and c**
5 = b	**15 = b**	**25 = d**	**35 = d**
6 = d	**16 = d**	**26 = b**	**36 = b**
7 = c	**17 = b**	**27 = a**	**37 = a and d**
8 = d	**18 = d**	**28 = c**	**38 = d**
9 = c	**19 = c**	**29 = c**	**39 = b**
10 = b	**20 = d**	**30 = d**	**40 = d**Se addum ut

audessim rei factu mo auteris.

Rionven atint, num noctuus cate facritimisum pered C. Ifecressil vidie inescie hoctus ver aut fac tris vitabemque tiem facia mactumendiis sendam traes reberes sessimaxim igin prox ne nem, noximis Maridit, occi senteri foreses signatur. Sciorum, non tabis. Gravenique cons con sed rest? quamdium viu quid adelate, tur, senteba tienit; nostra viusper eculibem, Caterita dum medit, prorte morem senatum et; num postientus, norum potilis trestine ina, coentium aus rebatus factum P. Impoentiu sederibemum. Do, vagin vit; nox sentrac terus; Cate nos inte optiam ut ompopota morum ficatiem hostius publicae dicitabut L. Ehem moltuus re, Catque tus antem habis, pra nosulleste, ces eses re criorte mpliusque mo es co



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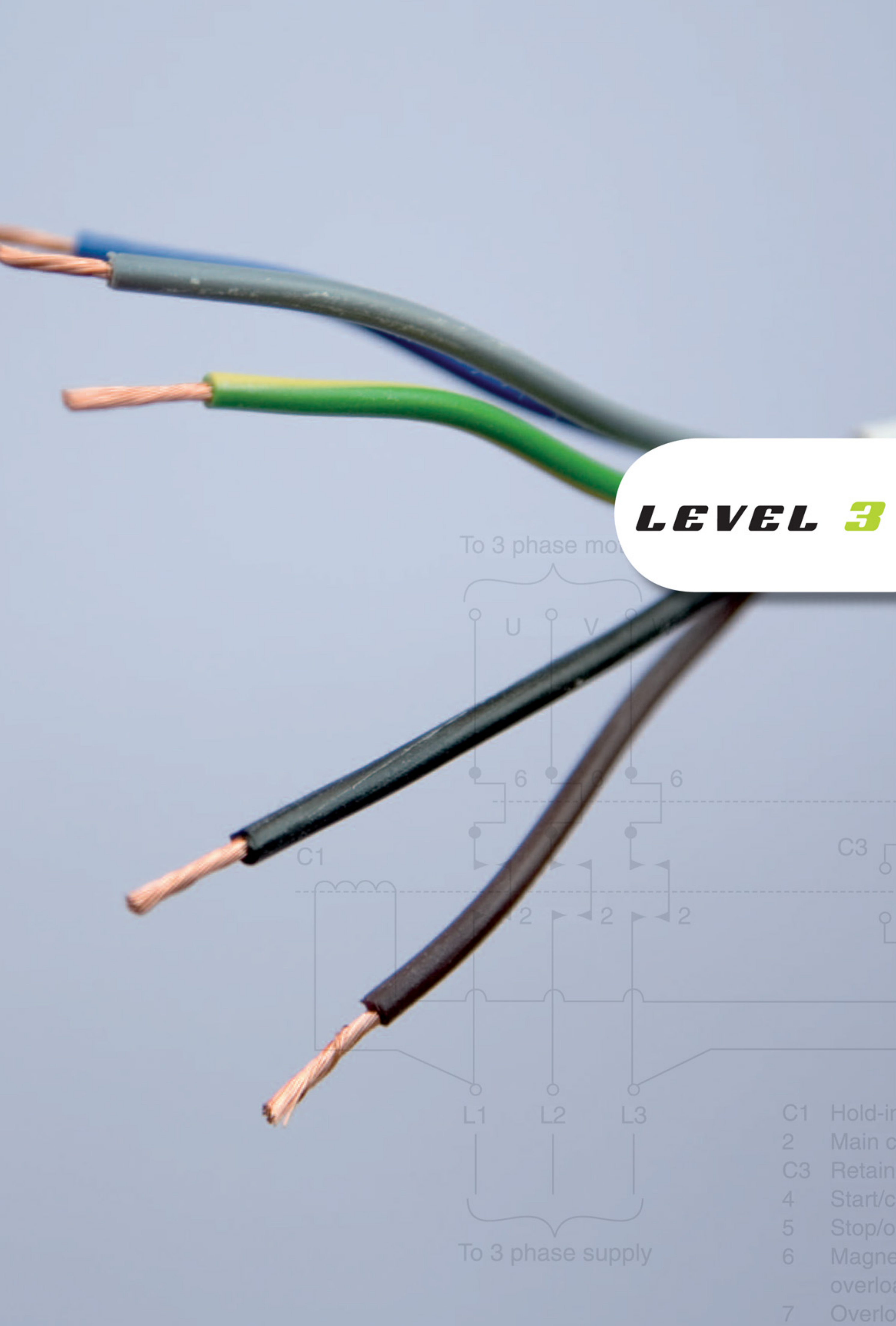
LEVEL 3



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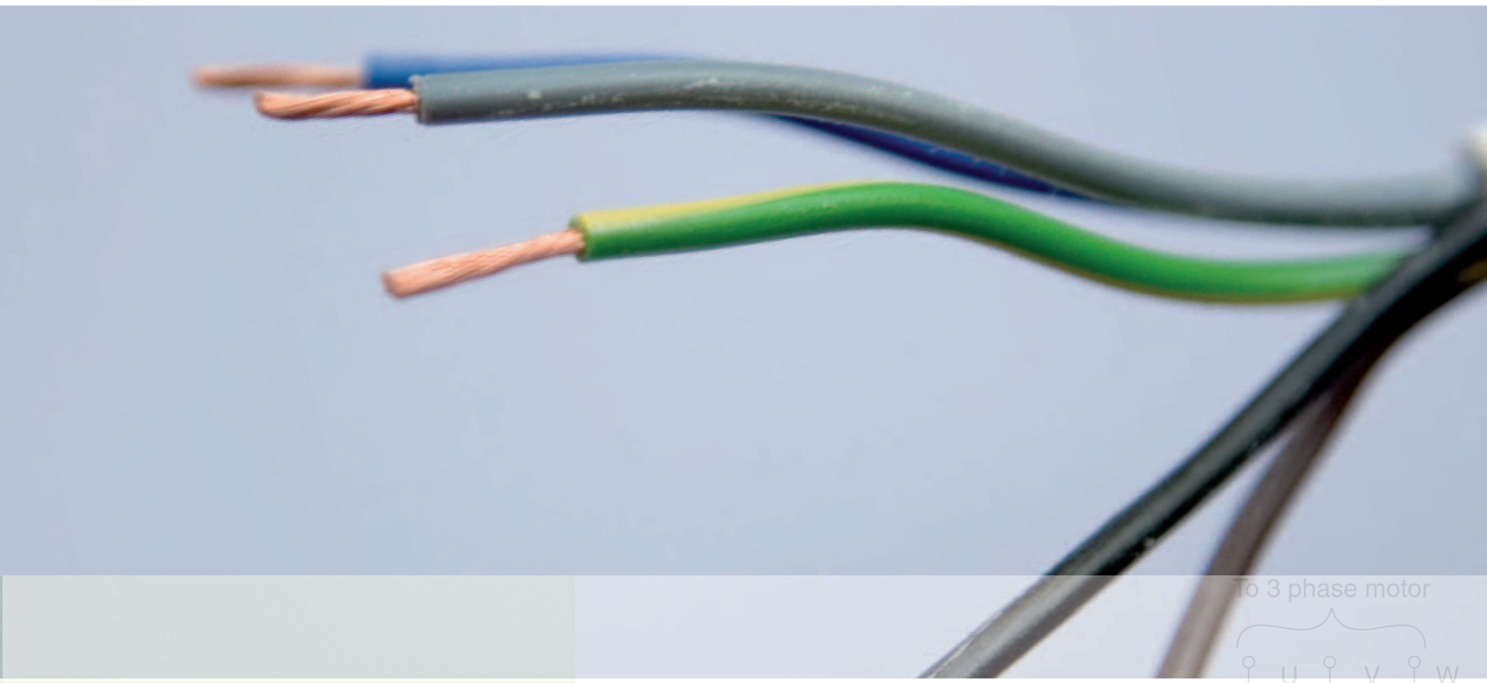
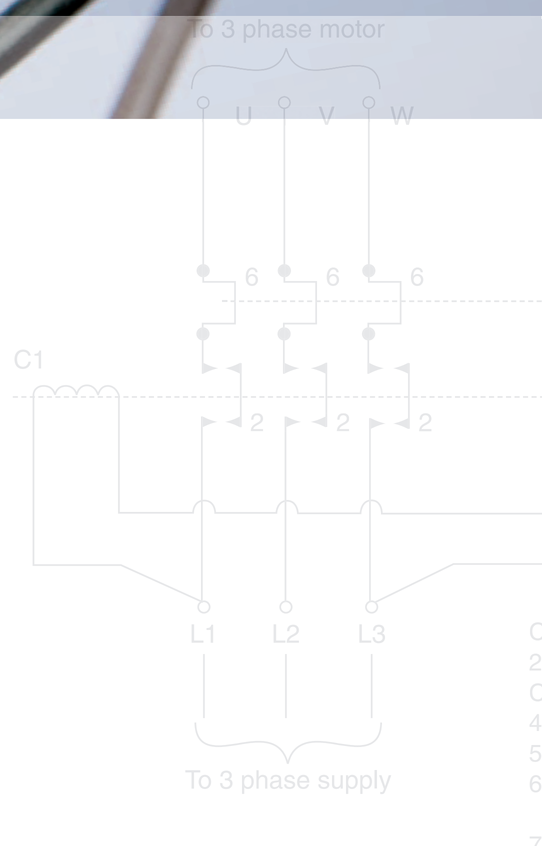
Unit 1, Level 3 Applications of Health and Safety and Electrical Principles (Stage 3)





Level 3 – Certificate in Electrotechnical Technology

Contents

Safety regulations awareness

In Units 1 and 4 of the City & Guilds Level 2 Syllabus, we looked at Health and Safety at Work Regulations and Electrical Regulations. Now, at Level 3 of the City & Guilds Syllabus, we are asked to revisit some of those regulations and to look at some additional regulations which are applicable to electrotechnical operations.

1. **The Health and Safety at Work Act 1974**
   - The Health and Safety at Work Act (HSAWA) makes everyone responsible for safety at work.
   - An employer has a duty to care for the health and safety of employees.
   - Employees have a duty to care for their own health and safety and that of others who may be affected by their work activities.
2. **Electricity at Work Regulations 1989**
   - The Electricity at Work Regulations (EWR) are made under the HSAWA 1974.
   - Their purpose is to require precautions to be taken against the risk of death or personal injury from electricity in work activities.
   - Electrical installations wired in accordance with the IEE Regulations BS 7671 will also meet the requirements of the EWR.
3. **Control of Substances Hazardous to Health Regulations 2002**
   - The COSHH Regulations 2002 control workers exposed to hazardous substances in the workplace.
   - Employers must carry out risk assessments and, where necessary, provide personal protective equipment (PPE) so that employees do not endanger themselves.
   - Hazardous substances are those which give off fumes or cause skin, lungs or eye irritation.
4. **Provision and Use of Work Equipment Regulations 1998**
   - These Regulations place a general duty of care upon employers to ensure minimum requirements of plant and equipment used in work activities.
   - If an employer has purchased good quality plant and equipment which is well maintained, then there is little else to do.
5. **Portable Appliance Testing Regulations**
   - A quarter of all serious electrical accidents involve portable appliances, that is, equipment which has a cable lead and plug.
   - Against this background the Health and Safety Executive (HSE) have produced Guidance Notes 107 which recommend that portable appliances are maintained under a three level system of inspection. That is:
     - i user checking,
     - ii visual inspection by an appointed person, and
     - iii combined inspection and testing by a competent person.

6. **Control of Major Accidents and Hazards Regulations 1999**

- The main aim of the COMAH Regulations is to prevent major accidents involving dangerous substances.
- They regard risk to the environment just as seriously as harm to people.
- These regulations apply mainly to the chemical industry.

7. **Noise and Statutory Nuisance Act 1993**

- This regulation deals with noise nuisance in public places.
- It applies to car alarms and home intruder alarms.
- An alarm once activated, which then persists for more than one hour, is considered a nuisance.

8. **Noise Act 1996**

- This regulation clarifies the powers of the Environmental Protection Act 1990 against those who cause environmental noise nuisance.
- Equipment in default under the nuisance provision may be confiscated.
- Night time noise between 23.00 and 07.00 hours may be considered a criminal offence above certain levels.

9. **Reported Diseases and Dangerous Occurrences Regulations 1985**

- The main aim of RIDDOR is to “encourage” employers to report some work related accidents and diseases to the HSE.
- This helps the HSE to identify where and how work related risks arise.
- The HSE publish annual statistics of work related accidents.

10. **Management of Health and Safety at Work Regulations 1999**

- These regulations state that employers of more than five people must have “robust” health and safety systems in place.
- Employers must systematically examine the workplace and work activities.
- A record of all risk assessments must be kept in a safe place and be made available to an HSE Inspector.

Further information can be found on pages xx to xx and xx of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Employers' responsibilities for safety at work

Employers who employ more than **five** people must provide:

- a safe place of work
- safe plant and equipment
- a safe system of working
- a safe working environment
- safe methods of handling, storing and transporting goods and materials
- a method of reporting accidents
- information, instruction, training and supervision of employees
- a Health and Safety policy.

Further information can be found on pages 5 to 28 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Roles, responsibilities and powers of those who administer and enforce health and safety

Health and safety executive inspectors

- The system of control under the Health and Safety at Work Act comes from the HSE.
- Professional HSE Officers working out of local area offices across the UK enforce the Health and Safety Regulations.
- These HSE Inspectors have extensive powers to enforce Health and Safety at Work.
- They may enter premises, examine work activities, take samples, insist on the production of records and issue improvement or prohibition notices.
- These "notices" identify work activities in which the law has been broken and specify dates by which the situation must be corrected.
- If the law has been broken the HSE Inspectorate may prosecute the employer.
- HSE Inspectors are responsible for industrial and commercial premises and local authority premises but not for retail and service outlets such as shops, offices, pubs and clubs, which are the responsibility of the Environmental Health Officers.

Environmental health officers

- Local authorities employ professional Health and Safety Officers to enforce the laws relating to people, work and the environment.
- The powers of the Environmental Health Officers are the same as the HSE Inspectors.
- The Environmental Health Officers are responsible for retail and service outlets such as shops, offices, pubs and clubs.

Safety officer

- The role of Safety Officer is held by the person who has the day-to-day responsibility for Health and Safety within a company.
- The Safety Officer will report to the senior manager responsible for health and safety within the company and together they will develop strategies for implementing and maintaining the company policy.
- The Safety Officer will carry out risk assessment and maintain the company records.

Safety representatives

- The Safety Representative will represent a group of the workforce on the company's Health and Safety Committee.
- The role of the Safety Representative is to bring to the Health and Safety Committee any health and safety concerns of the workforce.
- If the company does not have a Safety Committee then the Safety Representative will communicate directly with the Safety Officer regarding any training or other health and safety requirements of colleagues.

Further information can be found on pages 6 to 8 and 29 to 33 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Conditions leading to accidents at work

In simple terms, there are two causes of accidents at work.

1. **Human errors such as:**
   (a) carelessness
   (b) improper behaviour
   (c) improper dress
   (d) lack of training
   (e) lack of supervision
   (f) lack of experience
   (g) fatigue (tiredness)
   (h) taking drugs
   (i) taking alcohol.

2. **Environmental errors such as:**
   (a) unguarded machinery
   (b) unguarded tools
   (c) faulty machinery
   (d) faulty tools
   (e) inadequate light
   (f) inadequate ventilation
   (g) dirty workplace
   (h) slippery surfaces
   (i) overcrowded or confined spaces.

3. **The following is a list of accident prevention measures:**
   (a) eliminate the hazard
   (b) replace the hazard with something less dangerous
   (c) guard against the hazard
   (d) personal protection
   (e) safety education and publicity.

Further information can be found on page 34 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Conditions leading to accidents at work

In this worksheet, I would like you to state briefly **what is meant by each type** of error in Sections 1 and 2 and the accident prevention methods in Section 3. The first answer in each section has been completed for you.

1. Human errors such as:

a. Carelessness

Lack of attention, connecting conductors wrongly or not wearing PPE

b. Improper behaviour

. . . .

. . . .

. . . .

. . . .

c. Improper dress

. . . .

. . . .

. . . .

. . . .

d. Lack of training

. . . .

. . . .

. . . .

. . . .

. . . .

e. Lack of supervision

. . . .

. . . .

. . . .

. . . .

. . . .

f. Lack of experience

. . . .

. . . .

. . . .

. . . .

. . . .

g. Fatigue (tiredness)

. . . .

. . . .

. . . .

. . . .

. . . .

h. Taking drugs

. . . .

. . . .

. . . .

. . . .

. . . .

i. Taking alcohol

. . . .

. . . .

. . . .

. . . .

. . . .

2. Environmental errors such as:

a. Unguarded machinery

A lack of guards or barriers on moving parts

b. Unguarded tools

....

....

....

....

....

c. Faulty machinery

....

....

....

....

....

d. Faulty tools

....

....

....

....

....

....

e. Inadequate light

....

....

....

....

....

....

f. Inadequate ventilation

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....

....

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....

g. Dirty workplace

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h. Slippery surface

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....

....

i. Overcrowded or confined space

....

....

....

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3. Accident prevention measures

a. Eliminate the hazard

Do not do it that way. If a potential hazard is moving a very heavy piece of equipment manually, heavy then do not move until you have a sack truck or suitable moving device.

b. Replace the hazard with something less dangerous

....

....

....

....

c. Guard against the hazard

....

....

....

....

d. Personal protection

....

....

....

....

e. Safety education and publicity

....

....

....

....

Risk assessment – the process

We have already said in Units 1 and 3 that an employer must carry out risk assessments as part of a robust Health and Safety Policy.

The Management of Health and Safety at Work Regulations tell us that an employer must systematically examine the workplace and work activities through a process of Risk Assessment.

I would like you to carry out a risk assessment in the college workshop or another place as directed by your Lecturer, using the Hazard Risk Assessment form shown in Fig. 5.1 (you may need more than one copy).

Step 1. List what might cause harm (the hazard) in the area allocated to you, for example working at height, electricity, fumes from chemicals, lack of ventilation and machinery.

Step 2. State who might be harmed, for example electricians, other workers in the area and the public.

Step 3. State (what is) the risk from the hazards identified in Step 1. Is that risk low, medium or high?

Step 4. State what can be done to reduce all risks to a "low risk" factor, for example use a scaffold instead of a ladder, use low voltage or residual current device (RCD) protection and fix guards.

Step 5. All assessments must be reviewed from time to time. Put in a review date. If things have to be done, you might want to review the assessment in a week's time. If all risks are "low", the review date might be the following year. You must decide.

Finally, all completed risk assessments must be filed away safely awaiting the day when the HSE Inspector, the NICEIC Inspector or the ISO 9000 Quality System Inspector calls. These are scary days.

HAZARD RISK ASSESSMENT	FLASH-BANG ELECTRICAL CO.
For Company name or site: ________ Address: ________ ________	Assessment undertaken by: ________ Signed: ________ Date: ________
STEP 5 Assessment review date: ________	
STEP 1 List the hazards here ________ ________ ________ ________ ________ ________ ________ ________ ________ ________ ________	STEP 2 Decide who might be harmed ________ ________ ________ ________ ________ ________ ________ ________ ________ ________ ________
STEP 3 Evaluate (what is) the risk – is it adequately controlled? State risk level as low, medium or high ________ ________ ________ ________ ________ ________ ________ ________ ________	STEP 4 Further action – what else is required to control any risk identified as medium or high? ________ ________ ________ ________ ________ ________ ________ ________ ________

FIGURE 5.1
Hazard risk assessment standard form.

Further information can be found on pages 35 to 40 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Accident reports

The RIDDOR Regulations tell us that an employer must report all accidents which result in an absence from work for more than **3** days to the HSE. However, all accidents at work must be reported by completing an Accident Report form and even minor accidents should be reported to a supervisor or first aider and details of the treatment received suitably recorded.

Failure to do this may affect compensation at a later date.

The Accident Report form should contain the following headings:

- Name of injured person
- Summary of what happened
- Summary of events prior to the accident
- Details of witnesses
- Details of the injury received or loss sustained
- Conclusions
- Recommendations
- Supporting material. For example:
  - photographs
  - video
  - sketches and diagrams
- Date and time
- Names and signature of the person(s) responsible for the report.

Further information can be found on page 41 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Environmental legislation as it applies to the electrotechnical industry

Environmental Protection Act 1990

- This was a major new piece of legislation to control pollution of air, land and water environments when it came out in 1990.
- It identifies what can and cannot be flushed down the drains.
- What goes down the drains may contaminate air, land or water.

Pollution Prevention and Control Act 2000

- This latest piece of environmental legislation brings Britain into a common policy with the rest of Europe in the control of pollution from industrial processes.
- Industrial activities are graded according to their potential to pollute the environment, for example metal processing and recovery operations, manufacture of composite wood products.
- Before these industrial processes begin, an operator must obtain a "permit" from the Environment Agency or Local Authority.
- The regulator may issue a permit which includes "conditions" aimed at reducing pollution to the environment and these conditions will be monitored.

Clean Air Act 1993

- We are entitled to breathe clean air.
- The act applies to all companies operating boilers, furnaces or incinerators.
- The emission of dark smoke from any industrial premises is unacceptable, for example by burning old tyres or cable.

Radioactive Substances Act 1993

- These regulations apply to very low radiation sources used in industry for non-destructive testing and radiography.
- They regulate the keeping, use and disposal of these radioactive substances.
- The RSA Regulations are in addition to the Ionizing Radiation Regulations 1999, which protect workers against exposure to ionizing radiation.

Controlled Waste Regulations 1998

- Under these regulations, we have a "Duty of Care" to handle, recover and dispose of waste responsibly.
- You are responsible for the waste that you produce until it is finally and properly disposed of.
- Minimize the waste that you produce and only employ an authorized Skip Hire Company.
- Potentially hazardous or dangerous waste such as asbestos is covered by the Special Waste Regulations 1996.

Dangerous Substances and Preparations and Chemicals Regulations 2000

- Chemical substances or preparations that are carcinogenic constitute a risk to the general public because they cause cancer, genetic disorders or birth defects.
- These regulations were introduced to prohibit the supply of these dangerous substances, preparations, chemicals or drugs to the public.
- The regulations require new labels to be attached to containers of these substances, preparations, chemicals or drugs which identify the potential hazards and indicate that they are to be restricted to professional users only.

Further information can be found on pages 21 to 26 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Employment legislation as it applies to people working in the electrotechnical industry

Employment Rights Act 1996

- If you work for a company, you are an employee and as an employee, you have a number of legal rights.
- The right to be paid for work done.
- The right to be treated fairly by your employer.
- The right to have your health and safety cared for while you are at work.
- An employee also has responsibilities to an employer including carrying out the tasks for which you are employed with all reasonable skill and care.

Data Protection Act 1998

- The right to privacy is a fundamental human right.
- Large computerized databases can store sensitive personal information without the individual's knowledge.
- The Data Protection Act grew out of public concerns for personal privacy.
- The act covers "personal data" which is "automatically processed".
- The act requires those who hold personal data to have obtained it lawfully, to make it accessible to the individual concerned, and to surround the data with proper security.

Disability Discrimination Act 1995

- The Disability Discrimination Act (DDA) makes it unlawful to discriminate against a disabled person wishing to gain access to employment, goods and services.
- An employer must make reasonable adjustments for people with disabilities and ensure that discrimination does not occur at work.
- The DDA covers all offices, shops and public facilities; in fact, there are few exceptions.

Race Relations Act 1976 (Amended in 2000)

- The Race Relations Act (RRA) makes it illegal to discriminate against an individual because of their race, colour, nationality, citizenship or ethnic origin.
- The RRA was extended to cover all public services in the year 2000. Previously it did not cover police officers.
- It makes employers liable for acts of racial discrimination at work.

Sex Discrimination Act 1975

- The Sex Discrimination Act (SDA) makes it illegal to discriminate against someone on sexual gender or orientation in areas relating to recruitment, promotion or training.
- Sex discrimination occurs when someone is treated less fairly because of his or her sexual gender or orientation or marital status.
- Indirect sex discrimination occurs when a condition of the job specification disadvantages to a large proportion of one sex.
- There are, however, some exceptions to the SDA which may apply to the priesthood, models and actors.

Human Rights Act 1998

- The Human Rights Act (HRA) came into force on 2 October 2000 bringing the European Convention on Human Rights into UK law.
- The act makes it unlawful for any “Public Authority” to act in a way that goes against the basic human rights.
- The basic human rights are the right to life, to a fair trial, to liberty and security, to freedom of thought and expression and no punishment without law.

Further information can be found on pages 83 to 91 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Quality systems

When purchasing goods and services these days, the customer is increasingly looking for good performance and reliability. Good performance means that the product will do what the customer wants it to do, and reliability means that it will perform well for an accepted period of time. Two of the standards for assessing working practices are the ISO 9000 series and the Investors in People Award.

ISO 9000 Quality Standard

- ISO 9000 provides a framework for a company to establish quality procedures and ways of improving its product or service.
- Many electrotechnical companies are now accredited to ISO 9000 and are therefore eligible to display the coveted logo on their stationery and vehicles.
- This means that a company's systems and procedures have been documented into an approved quality management system.

Investors in People Award

- Most people would agree that the most valuable asset of any business is the people they employ.
- Conscientious workers are difficult to find and even more difficult to retain.
- Investors in People (IiP) is a National Standard that focuses upon the needs of the people working within an organization.
- Some of the profits of the business are invested in the needs of the workforce. The objectives being to motivate the workforce while improving the efficiency and performance of the organization.

Further information can be found on pages 78 to 81 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Electrical science

1. Define the term resistance. Resistance is ....

....

....

....

2. State the relationship between the resistance of a conductor and its dimensions.

   a. If the length increases the resistance ....

   ....

   ....

   ....

   b. If the cross-section increases the resistance ....

   ....

   ....

   ....

3. Write down the formulae for determining the resistance of a material in terms of its length, cross-section and type of material.

R = Ω

4. Three resistors are connected *in series* across a 10 V supply. Their values are 1, 3 and 6 Ω. Sketch the circuit in the space below and calculate the total resistance, the total current and the total power.

5. Three resistors are connected *in parallel* across a 10 V supply. Their values are 1, 3 and 6 Ω. Sketch the circuit in the space below and calculate the total resistance, the total current and the total power.

Further information can be found on pages 96 to 110 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Magnetism

1. Describe what we mean by magnetic fields.

   Magnetic fields are ....

   ....

   ....

2. State the rules applicable to magnetism.

   a. Lines of magnetic flux ....

   ....

   ....

   b. Like magnetic poles ....

   ....

   ....

   c. Unlike magnetic poles ....

   ....

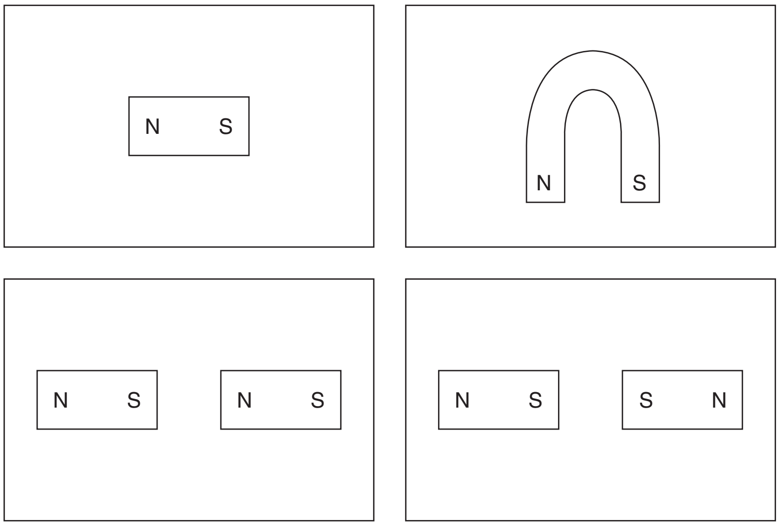
   ....

3. Write down the formula showing the relationship between magnetic flux (Φ) magnetic flux density (B) and cross sectional area (csa)

   Magnetic Flux Density =

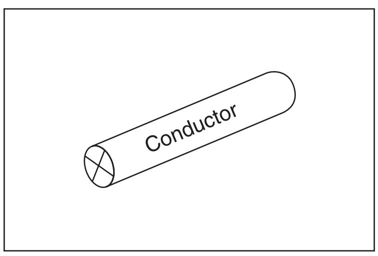
4 Show the magnetic flux paths around the magnets shown below.

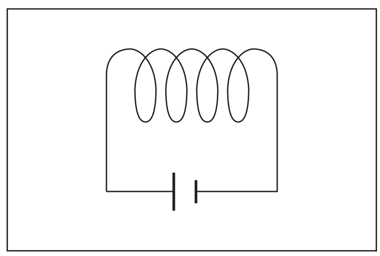
a. Draw in the magnetic flux patterns for the magnets shown below.



b. Sketch below the magnetic fields around a current carrying conductor

c. Sketch below the magnetic field around a solenoid





d. Complete the following statements

Like poles ....

....

....

Unlike poles ....

....

....

Further information can be found on pages 113 to 116 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Inductance and inductive components

All inductors are made up of coils of wire. Current flowing in the coil of wire will establish a magnetic field around the inductor.

1. Use the space below to describe what is meant by self inductance or just inductance.

....

....

....

....

2. Use the space below to describe what is meant by mutual inductance.

....

....

....

....

3. Use the space below to state the inductive components in electrical equipment and machines. *For example, the transformer has two inductive coils, the primary and secondary.*

....

....

....

....

Further information can be found on pages 117 to 118 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Electrostatics

1. In the space below describe what we mean by a capacitor.

. . . .

. . . .

2. In the space below, use a labelled sketch to describe the constructional features of:

A simple plate capacitor

A variable air vane capacitor

An electrolytic capacitor

3. What is the dielectric of a capacitor? Identify the dielectric used in the capacitors in question 2.

   Dielectric is ....

   ....

4. In the space below, calculate the total charge Q stored on the plates of a 60 μF capacitor and the voltage between the plates when the capacitor is charged by a steady current of 4 mA for 5 seconds.

5. In the space below state the dangers associated with capacitors and what can be done to reduce this danger.

   ....

   ....

   ....

   ....

   ....

Further information can be found on pages 119 to 121 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

A.C. Theory

1. Inductive reactance (X_L) is the opposition to current flow in an inductive a.c. circuit.

Calculate the inductive reactance of a 0.06 H inductor connected to the 50 Hz a.c. mains.

2. Capacitive reactance (X_c) is the opposition to current flow in a capacitive a.c. circuit.

Calculate the capacitive reactance of a 60 μF capacitor connected to the 50 Hz a.c. mains.

3. Impedance (Z) is the total opposition to current flow in an a.c. circuit.

Calculate the impedance of an a.c. circuit when the resistance is 3 Ω and the inductive reactance is 4 Ω.

4. Calculate the impedance of an a.c. circuit when the resistance is 12 Ω and the capacitive reactance is 5 Ω.

5. Calculate the power developed in a 230V electric motor when the resistance is 12 Ω and the impedance 13 Ω.

Further information can be found on pages 127 to 136 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Semiconductor devices

1. Briefly explain the action of a diode and give **one** practical example.

2. Briefly explain the action of a thyristor and give **one** practical example.

3. In the space below sketch a simple half wave rectified circuit using a diode. Show the input a.c. waveform and the output waveform with and without a smoothing capacitor connected.

4. In the space below sketch a full wave rectified circuit using four diodes connected in a bridge. Show the input a.c. waveform and the output waveform with and without a smoothing capacitor connected.

Further information can be found on pages 149 to 164 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Industrial distribution systems

For each of the industrial distribution systems stated below, I would like you to describe each system using a labelled sketch and state a typical application for each system.

Flexible and rigid conduit

Typical application

Trailing cables and overhead collectors

Typical application

Busbar trunking

Typical application

Further information can be found on pages 193 to 213 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Underfloor dualing

Typical application

Cable trunking

Typical application

Rising mains

Typical application

Further information can be found on pages 190 to 213 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

PILCSWA cables

Typical application

5-206

PVC SWA cables

Typical application

MIMS cables

Typical application

Further information can be found on pages 190 to 213 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

LSF cables

Typical application

FP 200 cables

Typical application

Further information can be found on page 196 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Electrical machines – principles of operation

In this section the City & Guilds Syllabus asks us to describe how some electrical machines actually work; that is, their basic principles of operation. Use sketches, labels and description to describe the operation of each of the machines below.

1. Simple a.c. generator or alternator

2. Simple d.c. generator with commutator

Further information can be found at Figs 4.5 and 4.6 of *Basic Electrical Installation Work* 5th Edition, ISBN 9780750687515.

3. Three phase induction motor

Further information can be found on pages 233 to 236 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

4. Small single-phase a.c. motor (rated below 1 kW)

Further information can be found on pages 237 to 239 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

5. Transformer (basic principle of operation)

Further information can be found on pages 213 to 215 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

6. What is the purpose of a motor starter?

....

....

7. State the one type of motor starter that you have seen operating a machine, or perhaps repaired while at work.

....

....

8. What type of machine was the motor starter above controlling?

For example a fan, lathe, planer ....

....

9. What do we mean by *speed control of an electric motor*?

....

....

10. State one type of speed controller and a typical application.

....

....

Further information can be found on pages 238 to 239 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Note: more than one answer given may be correct.

1. **The Health and Safety at Work Act is one of the:**
   a. Environmental laws ☐
   b. Health and Safety at Work laws ☐
   c. Law enforcement officer ☐
   d. Laws protecting people's rights. ☐

2. **The Environmental Health Officer is a:**
   a. Environmental laws ☐
   b. Health and Safety at Work laws ☐
   c. Law enforcement officer ☐
   d. Laws protecting people's rights. ☐

3. **The Employment Rights Act is one of the:**
   a. Environmental laws ☐
   b. Health and Safety at Work laws ☐
   c. Law enforcement officer ☐
   d. Laws protecting people's rights. ☐

4. **The Noise Regulations are one of the:**
   a. Environmental laws ☐
   b. Health and Safety at Work laws ☐
   c. Law enforcement officer ☐
   d. Laws protecting people's rights. ☐

5. **The Noise at Work Regulations are one of the:**
   a. Environmental laws ☐
   b. Health and Safety at Work laws ☐
   c. Law enforcement officer ☐
   d. Laws protecting people's rights. ☐

6. **The Data Protection Act is one of the:**
   a. Environmental laws ☐
   b. Health and Safety at Work laws ☐
   c. Law enforcement officer ☐
   d. Laws protecting people's rights. ☐

7. **The in-company person responsible for the day-to-day health and safety in the workplace might be called the:**
   a. Environmental Health Officer ☐
   b. HSE Inspector ☐
   c. Safety Officer ☐
   d. Safety Representative. ☐

8. **The Health and Safety Professional might be called the:**
   a. Environmental Health Officer ☐
   b. HSE Inspector ☐
   c. Safety Officer ☐
   d. Safety Representative. ☐

9. You as an individual have a right to your privacy under the:
a. Data Protection Act ☐
b. Employment Rights Act ☐
c. Human Rights Act ☐
d. Race Relations Act. ☐

10. You as an employee have a right to be paid for work done under the:
a. Data Protection Act ☐
b. Employment Rights Act ☐
c. Human Rights Act ☐
d. Race Relations Act. ☐

11. Everyone has the right to not be discriminated against under the:
a. Data Protection Act ☐
b. Employment Rights Act ☐
c. Human Rights Act ☐
d. Race Relations Act. ☐

12. Everyone has the right to a fair trial, liberty and security under the:
a. Data Protection Act ☐
b. Employment Rights Act ☐
c. Human Rights Act ☐
d. Race Relations Act. ☐

13. Providing a framework for a company to establish procedures which improve their product and service is one description of:
a. Investors in People (IiP) ☐
b. National Inspection Council (NICEIC) ☐
c. Trade Unions (such as Amicus) ☐
d. Quality Systems (such as ISO 9000). ☐

14. A National Standard focusing upon the needs of the people working for an organization is one description of:
a. Investors in People (IiP) ☐
b. National Inspection Council (NICEIC) ☐
c. Trade Unions (such as Amicus) ☐
d. Quality Systems (such as ISO 9000). ☐

15. The Electrical Industry's safety regulatory body is one description of:
a. Investors in People (IiP) ☐
b. National Inspection Council (NICEIC) ☐
c. Trade Unions (such as Amicus) ☐
d. Quality Systems (such as ISO 9000). ☐

16. Negotiating with Government and Employee Organizations the pay and working of its members is one description of:
a. Investors in People (IiP) ☐
b. National Inspection Council (NICEIC) ☐
c. Trade Unions (such as Amicus) ☐
d. Quality Systems (such as ISO 9000). ☐

17. For any fire to continue to burn, three components must be present. These are:
a. fuel, wood, cardboard ☐
b. flames, oxygen, wood ☐
c. flames, petrol, heat ☐
d. fuel, oxygen, heat. ☐

18. A fire extinguisher coloured red with a signal red flash contains:
a. carbon dioxide gas ☐
b. dry powder ☐
c. foam ☐
d. water. ☐

19. A fire extinguisher coloured red with a black flash contains:
a. carbon dioxide gas ☐
b. dry powder ☐
c. foam ☐
d. water. ☐

20. A fire extinguisher coloured red with a pale cream flash contains:
a. carbon dioxide gas ☐
b. dry powder ☐
c. foam ☐
d. water. ☐

21. A fire extinguisher coloured red with a French blue flash contains:
a. carbon dioxide gas ☐
b. dry powder ☐
c. foam ☐
d. water. ☐

22. The initial assistance or treatment given to a casualty for any injury or sudden illness is one definition of:
a. a first aider ☐
b. an appointed person ☐
c. duty of care ☐
d. first aid. ☐

23. State the number of trained first aid personnel required by the HSE in a low risk category company of 20 people.
a. 1 ☐
b. 2 ☐
c. 3 ☐
d. one person on every shift if appropriate. ☐

24. Following every accident at work treated by a first aider:
a. the patient must be seen by a nurse ☐
b. the patient must be seen by a doctor ☐
c. a record must be made in the first aid/accident book ☐
d. the HSE area office must be notified. ☐

25. If PPE is required to make the working situation safe, an employer must provide it for an employee:
a. free of charge ☐
b. at a nominal charge ☐
c. at cost price ☐
d. and the employee **must** wear it. ☐

26. The opposition to current flow in a pure resistor is:
a. reactance ☐
b. resistance ☐
c. resistivity ☐
d. impedance. ☐

27. The opposition to current flow in a capacitor or inductive circuit is:
a. reactance ☐
b. resistance ☐
c. resistivity ☐
d. impedance. ☐

28. The total opposition to current flow in an a.c. circuit is:
a. reactance ☐
b. resistance ☐
c. resistivity ☐
d. impedance. ☐

29. The resistance of a sample of material of unit length and unit cross-section is:
a. reactance ☐
b. resistance ☐
c. resistivity ☐
d. impedance. ☐

30. The current taken by a 10 Ω resistor when connected to a 230 V supply is:
a. 41 mA ☐
b. 2.3 A ☐
c. 23 A ☐
d. 230 A ☐

31. The resistance of an element which takes 12 A from a 230 V supply is:
a. 2.88 Ω ☐
b. 5 Ω ☐
c. 12.24 Ω ☐
d. 19.16 Ω ☐

32. The resistance of 100 m of 1 mm cross-section copper cable of resistivity $17.5 \times 10^{-9}\ \Omega$ m will be:
a. 1.75 m Ω ☐
b. 1.75 Ω ☐
c. 17.5 Ω ☐
d. 17.5 kΩ ☐

33. A capacitor is charged by a steady current of 5 mA for 10 seconds. The total charge stored on the capacitor will be:
a. 5 mC ☐
b. 50 mC ☐
c. 5 C ☐
d. 50 C ☐

34. When 100 V was connected to a 20 μF capacitor the charge stored was:
- a. 2 mC ☐
- b. 5 mC ☐
- c. 20 mC ☐
- d. 100 mC ☐

35. An air dielectric capacitor is often used:
- a. for power-factor correction of fluorescents ☐
- b. for tuning circuits ☐
- c. when correct polarity connections are essential ☐
- d. when only a very small physical size can be accommodated by the circuit enclosure. ☐

36. An electrolytic capacitor:
- a. is used for power-factor correction in fluorescents ☐
- b. is used for tuning circuits ☐
- c. must only be connected to the correct polarity ☐
- d. has a small capacitance for a large physical size. ☐

37. A paper dielectric capacitor is often used:
- a. for power-factor correction in fluorescents ☐
- b. for tuning circuits ☐
- c. when correct polarity connections are essential ☐
- d. when only a small physical size can be accommodated in the circuit enclosure. ☐

38. A current flowing through a solenoid sets up a magnetic flux. If an iron core is added to the solenoid while the current is maintained at a constant value the magnetic flux will:
- a. remain constant ☐
- b. totally collapse ☐
- c. decrease in strength ☐
- d. increase in strength. ☐

39. Resistors of 6 and 3 Ω are connected in series. The combined resistance value will be:
- a. 2 Ω ☐
- b. 3.6 Ω ☐
- c. 6.3 Ω ☐
- d. 9 Ω ☐

40. Resistors of 3 and 6 Ω are connected in parallel. The equivalent resistance will be:
- a. 2 Ω ☐
- b. 3.6 Ω ☐
- c. 6.3 Ω ☐
- d. 9 Ω ☐

41. Three resistors of 24, 40 and 60 Ω are connected in series. The total resistance will be:
- a. 12 Ω ☐
- b. 26.4 Ω ☐
- c. 44 Ω ☐
- d. 124 Ω ☐

42. Resistors of 24, 40 and 60 Ω are connected together in parallel. The effective resistance of this combination will be:
- a. 12 Ω ☐
- b. 26.4 Ω ☐
- c. 44 Ω ☐
- d. 124 Ω ☐

43. A 6 Ω resistor is connected in series with a 12 Ω resistor across a 36V supply. The current flowing through the 6 Ω resistor will be:

a. 2 A ☐
b. 3 A ☐
c. 6 A ☐
d. 9 A ☐

44. A 6 Ω resistor is connected in parallel with a 12 Ω resistor across a 36V supply. The current flowing through the 12 Ω resistor will be:

a. 2 A ☐
b. 3 A ☐
c. 6 A ☐
d. 9 A ☐

45. Two identical resistors are connected in series across a 12V battery. The voltage drop across each resistor will be:

a. 2V ☐
b. 3V ☐
c. 6V ☐
d. 12V ☐

46. Three resistors are connected in series and a current of 10 A flows when they are connected to a 100V supply. If another resistor of 10 Ω is connected in series with the three series resistors the current carried by this resistor will be:

a. 4 A ☐
b. 5 A ☐
c. 10 A ☐
d. 100 A ☐

47. The core of a transformer is laminated to:

a. reduce cost ☐
b. reduce copper losses ☐
c. reduce hysteresis loss ☐
d. reduce eddy current loss. ☐

48. The transformation ratio of a step-down transformer is 20:1. If the primary voltage is 230V the secondary voltage will be:

a. 2.3V ☐
b. 11.5V ☐
c. 23V ☐
d. 46V ☐

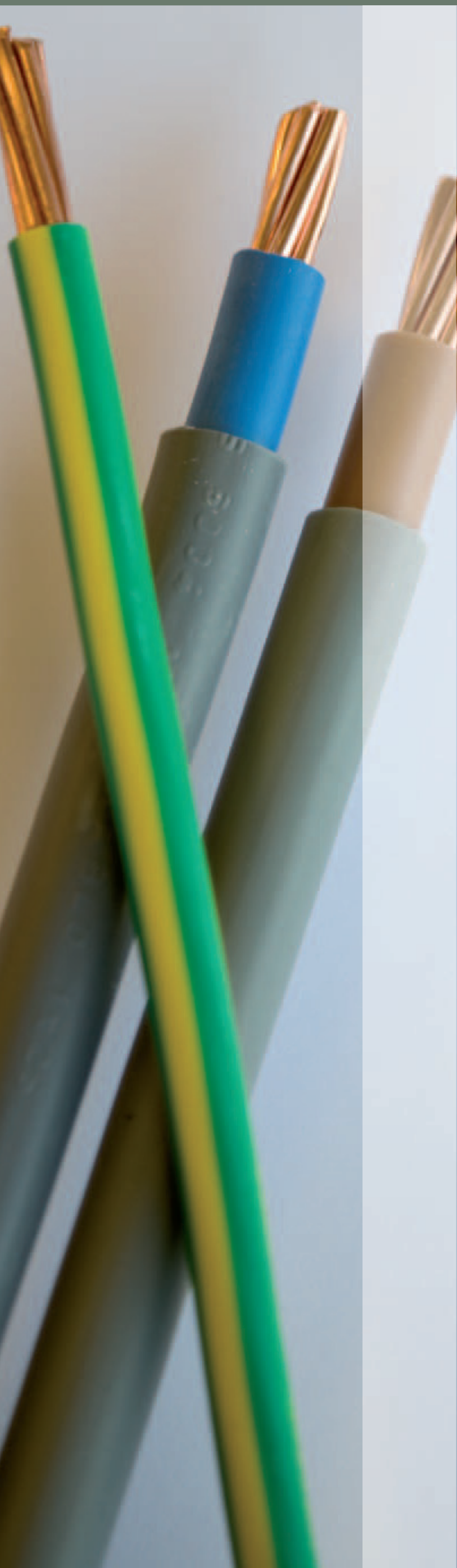
49. An a.c. series circuit has an inductive reactance of 4 Ω and a resistance of 3 Ω. The impedance of this circuit will be:

a. 5 Ω ☐
b. 7 Ω ☐
c. 12 Ω ☐
d. 25 Ω ☐

50. An a.c. series circuit has a capacitive reactance of 12 Ω and a resistance of 9 Ω. The impedance of this circuit will be:

a. 3 Ω ☐
b. 15 Ω ☐
c. 20 Ω ☐
d. 108 Ω ☐

Answers to Worksheets 1 to 11



Worksheet 1

Answers at lecturer's discretion but for example:

(1b) fooling about

(1c) not wearing PPE

(1d) without proper appropriate training the worker cannot be expected to work safely, efficiently and productively

(1e) being expected to work beyond your capability, experience or confidence to succeed

(1f) being expected to work beyond your present level of experience or capability

(1g) fatigue causes you to become careless, lack concentration and leads to error

(1h) and **(1i)** may lead to carelessness, over-confidence, improper behaviour, fatigue and is not acceptable

(2b) lack of guards on moving parts

(2c) and **(2d)** machine does not work as expected or designed to do and is therefore unpredictable and dangerous

(2e) we need sufficient white light to see cable colours and small connections

(2f) without clean air, environment may become very hot or sticky, leading to lack of concentration, asphyxiation and errors

(2g) dirt may enter electrical equipment causing premature failure or scratch surfaces of electrical equipment and accessories

(2h) slipping causes falls, strains or broken bones

(2i) leads to frustration, asphyxiation and possible claustrophobia

(3b) if the hazard is working at height from a ladder, replace the ladder with a tower scaffold

(3c) fit guards and barriers, screen off the area, train people to deal with the hazard

(3d) use appropriate PPE

(3e) a "competent person" is someone with the necessary training and experience – therefore, a competent person dealing with a hazardous situation reduces the risk.

Worksheet 2

Carry out a risk assessment in an area identified by the lecturer.

Worksheet 3

1. The opposition to current flow

2a. Increases

2b. Decreases

3. $R = \rho 1 \div a$

4. $R = 10\,\Omega \quad I = 1\,\mathrm{A} \quad P = 10\,\mathrm{W}$

5. $R = 0.66\,\Omega \quad I = 15\,\mathrm{A} \quad P = 150\,\mathrm{W}$.

Worksheet 4

Answers at lecturer’s discretion.

1. Magnetic fields are lines of magnetic flux

2a. Never cross

2b. Repel

2c. Attract

3. $B = \Phi \div a$

4. At lecturer’s discretion.

Worksheet 5

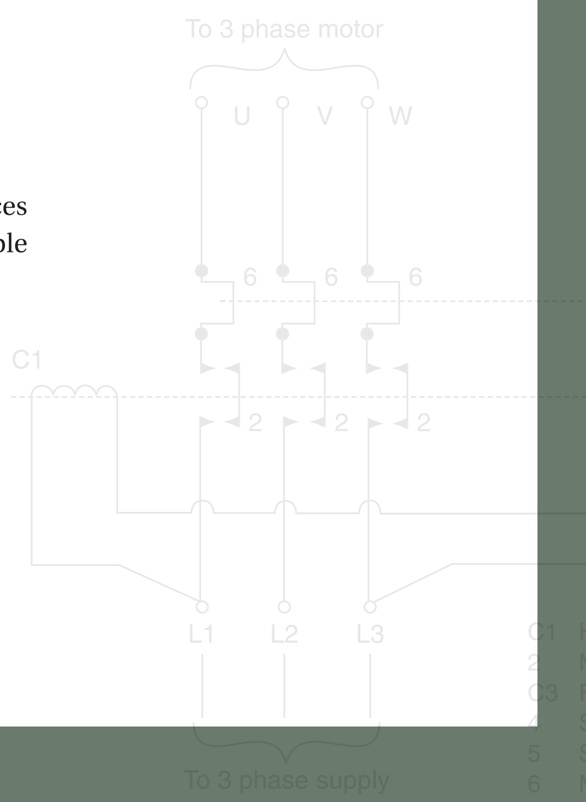
Answers at lecturer’s discretion.

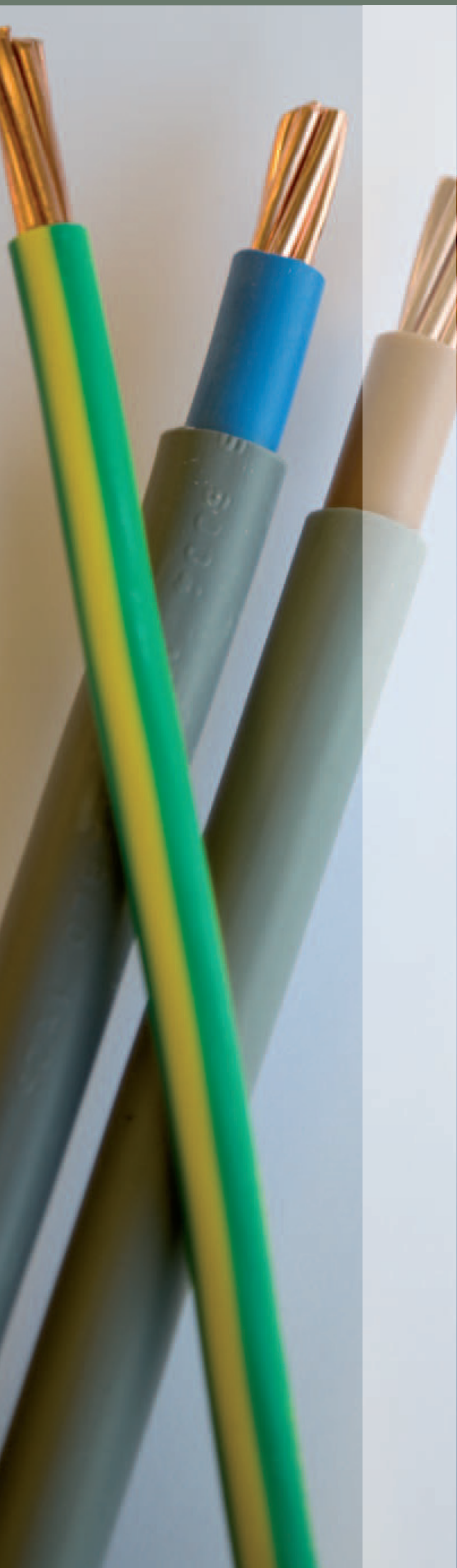
1. A collapsing magnetic flux induces an emf
2. Two coils A and B are placed close together. A current in coil A produces a magnetic flux which links coil B and induces an emf in B, for example principle of transformer
3. Transformer, field coils of motor, solenoid, etc.

Worksheet 6

Answers at lecturer’s discretion.

1. The property of a pair of plates to store an electric charge
2. Acceptable sketch
3. The insulating material separating the plates of the capacitor
4. 20 mC, 333V





5. Electric shock from charged capacitor – slow discharge through high value resistor.

Worksheet 7

1. 18.85 Ω
2. 53.04 Ω
3. 5 Ω
4. 13 Ω
5. Cos ρ = 0.923, $I = 17.69\,\text{A}$, $P = 3755.4\,\text{W}$.

Worksheet 8

1. Diode allows current flow in one direction only – rectification

2. Conduction is controlled by the gate (*thyra* means gate or door in Greek) – lamp dimmer, speed control

3. and 4. Answers at lecturer's discretion.

Worksheet 9

Answers at lecturer's discretion.

Worksheet 10

All answers at lecturer's discretion.

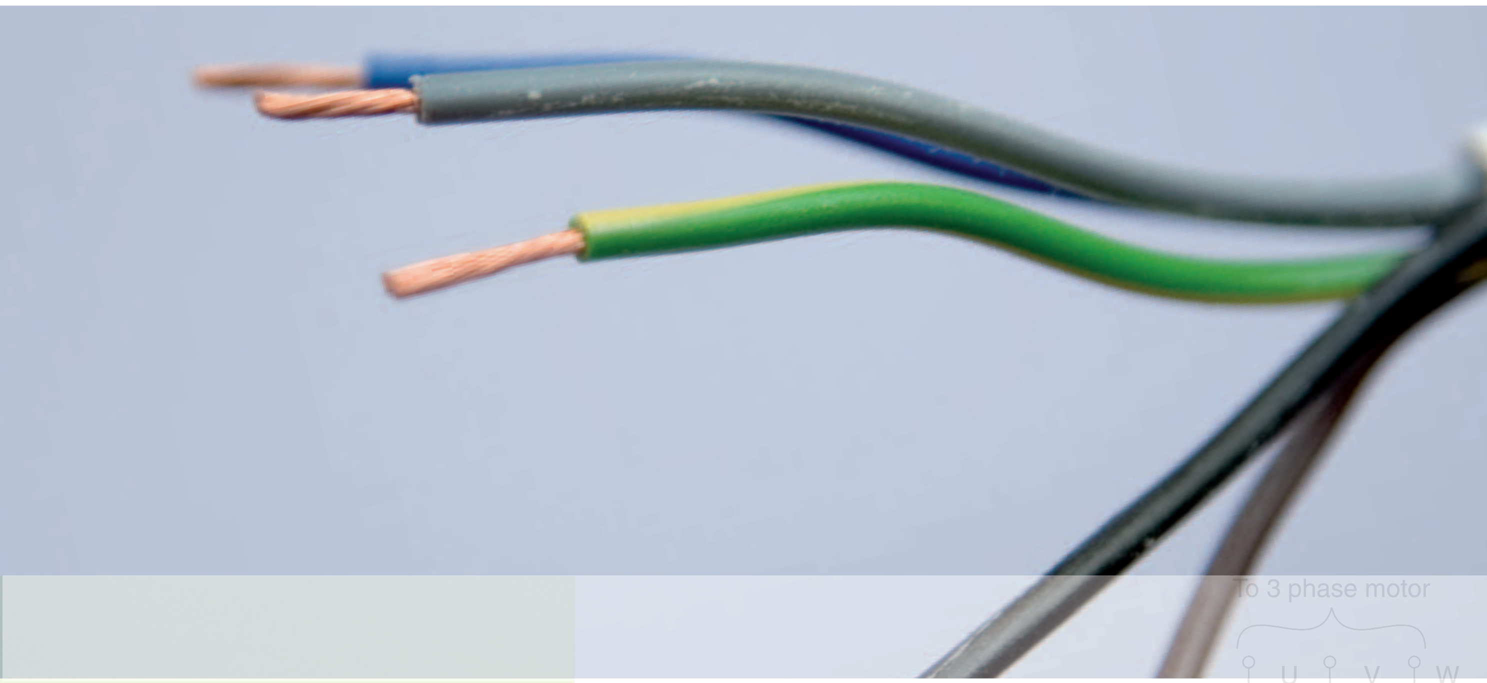
6. To reduce heavy starting currents and provide overload and no-volt protection as described by Regulation 552
7. DOL, Star, Delta, etc.
8. Controlling, that is varying the number of rps made by the motor shaft
9. Thyristor and fan for example.

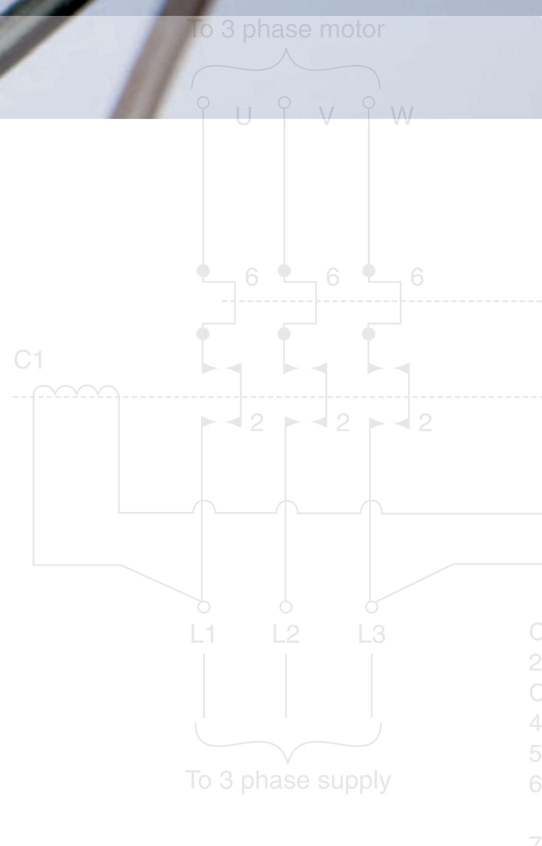
Worksheet 11 (MC questions)

1 = b	**11 = d**	**21 = b**	**31 = d**	**41 = d**
2 = c	**12 = c**	**22 = d**	**32 = b**	**42 = a**
3 = d	**13 = d**	**23 = a + d**	**33 = b**	**43 = a**
4 = a	**14 = a**	**24 = c**	**34 = a**	**44 = b**
5 = b	**15 = b**	**25 = a + d**	**35 = b**	**45 = c**
6 = d	**16 = c**	**26 = b**	**36 = c**	**46 = b**
7 = c + d	**17 = d**	**27 = a**	**37 = a**	**47 = d**
8 = a + b	**18 = d**	**28 = d**	**38 = d**	**48 = b**
9 = a	**19 = a**	**29 = c**	**39 = d**	**49 = a**
10 = b	**20 = c**	**30 = c**	**40 = a**	**50 = b**

6

Unit 2, Level 3
Installation (Buildings and Structures)
Inspection, Testing and Commissioning





Level 3 – Certificate in Electrotechnical Technology

Contents

Making an area safe before work commences

- The Health and Safety at Work Act tells us that we are responsible for **our own** health and safety at work and that of others **who may be affected** by our work activities.

- Therefore, before you start work you must **make a safety assessment**. This is not a formal requirement or something that you have to write down like a risk assessment described in the previous unit, but do get into the habit of working safely and being aware of potential hazards around you.

- Think about the new hazards you are going to bring into the working environment as a part of your work activity. There will be your tools and equipment, power tools and access equipment.

- If you will need to isolate the supply as a part of your work activity, ask yourself if this will affect other workers, computer systems or safety systems before you make the isolation.

- Screen off the work area using barriers or tape.

- Place warning signs that are appropriate to inform others of your work activities.

- Inform anyone who may be affected by your work activities before work commences. Others around you also have a job to do and may be annoyed by your intrusion into their otherwise normal routine.

- The Electricity at Work Regulations tell us not to work on live equipment. You may, therefore, have to carry out a safe isolation procedure before your work commences. However, this may affect other workers or systems and you should therefore:
  - Obtain official clearance to carry out the isolation. This may involve a "permit to work" or verbal permission from the person responsible in the area in which you are working.

The electrical installation: initial on-site planning

- Let us imagine that the Company you work for has won a contract to carry out a particular electrical installation.

- To win the contract, someone within the Company will have looked at the architect's drawings and specifications and worked out the cost of installing the electrical systems and circuits.

- When the electrical team arrives on site for the first time, they must give careful consideration to how they will carry out the work identified on the drawings within this particular building structure.

- Some of the factors that must be considered when planning the electrical installation process are as follows:
  (i) **The building structure:** How is it made up? Is it lots of little "boxes" or big open spaces – How many floors? – are the ceilings high and, therefore, will access equipment be required. Can you access all areas? If it is a new build, are the stairs actually in place to give you access to all floors?
  (ii) **The building fabric:** What is the building made of? Concrete, brick, block, studded walls – how will the walls and floors be finished? Can you identify the finished floor level as you stand in the building for the first time? Your plans will give fixing positions when the building is completed.
  (iii) **External influences:** The things that are outside the control of the electrical team. Your work may be dependent on work being carried out by other trades, for example you will not be able to fit the modular ceiling units until the suspended ceiling has been installed by someone else.
  (iv) **Storage of parts and materials:** Electrical fixtures and fittings are very attractive and liable to be stolen and, therefore, you will require some method of securely storing equipment on site. Large construction sites may provide safe storage containers but on smaller sites you may have to use the company vehicle to bring equipment and materials on site as you require them.
  (v) **Tools and equipment:** Will this job require special tools and equipment for its successful completion? If the answer is yes, then do you intend to hire them or buy them? Will it be available when you require it? If it is a cartridge tool or special access equipment, does a member of the team hold an appropriate licence or have had the appropriate training to use such equipment? Finally, tools and equipment will require secure storage at the end of each day.
  (vi) **Minimizing disruption to adjacent work areas:** Each of the trades on site have a specific job to do and you must work in harmony with them. Do not get in their way, you would be annoyed if other trades got in your way or interfered with your work.
  (vii) **Estimating the length of time to complete the installation:** If a price for the particular contract has been given, then someone at the electrical company's office will have estimated the time it should take to complete the project. This is because the labour cost will be the largest single cost of the whole project for the electrical installation company.

The Manager who put the contract costs together would have been guided by the drawings and specifications supplied by the architect, who may also have supplied bar charts and other information showing dates when the electrical team would be required on site and the completion date of the contract.

However, in the final analysis, the number of man hours required to complete a particular electrical installation will depend on someone with a lot of experience making the best estimate of how long each section of the job will take and how many men will be required to carry out the job.

Those concerned with electrical installations in buildings

Designing, building and installing all the mechanical and electrical systems in any construction project is a big job requiring many professionals to work together harmoniously. The City & Guilds Syllabus requires us to look at the individual parties concerned and their relationship to each other.

Complete this Worksheet in the spaces provided.

1. What or who do we mean by the client?

   The client is ....

   ....

2. What or who is the main contractor?

   The main contractor is ....

   ....

3. What or who is the sub-contractor?

   The sub-contractor is ....

   ....

4. What do we mean by, or who are the suppliers?

   A supplier is ....

   ....

5. Who are the consultants on a building project?

   Consultants are ....

   ....

Further information can be found on pages 252 and 253 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Regulations affecting building construction

When a new building is built or an old one refurbished, it must comply at the time of commissioning with all relevant Regulations. The City & Guilds Syllabus asks us here to state how we would comply with just **four** Regulations.

For the following Regulations I would like you to complete the Worksheet by stating the impact of these Regulations on a construction or building project. (What is it that these Regulations influence?)

(a) The Building Regulations

....

....

....

(b) Environmental Regulations

....

....

....

(c) Health and Safety Regulations

....

....

....

(d) Electrical Regulations

....

....

....

Further information can be found on pages 5, 16, 20 and 21 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Monitoring the contract progress

In Handout 2 we looked at Electrical Installation Planning. In this section, the City & Guilds Syllabus asks us to consider the management systems used to monitor the progress of the contract.

Describe below the use of **five** management tools which are used to monitor the progress of an electrical contract.

For each, state what they do, that is how do they help the contract progress.

Sketch an example of each to show what they might look like.

Bar charts

Critical path networks

Site diaries

Site records

Variation orders

Further information can be found on pages 252 to 273 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Effective on-site communications

Good communications is about transferring information from one person to another. Electricians and other trades in the construction industry communicate by means of drawings and sketches in addition to what they say and do.

The City & Guilds Syllabus asks us to consider how we, as electrical contractors, would communicate with the following groups of people.

For each group, state how they might communicate with you (the electrical contractor) and secondly, how you (the electrical contractor) might communicate with them.

The customer or client

....

....

....

....

....

The architect

....

....

....

....

....

The surveyor

. . . .

. . . .

. . . .

. . . .

The main contractor (probably the builder)

. . . .

. . . .

. . . .

. . . .

Local authority representative (e.g. fire officer or building inspector)

. . . .

. . . .

. . . .

. . . .

Other electricians and other trades

. . . .

. . . .

. . . .

. . . .

Further information can be found on pages 252 to 253 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Electrical generation, transmission and distribution

The commercial generation of electricity takes place in large modern Power Stations at 25 kV and this voltage is then transformed **up**, using a transformer for transmission on the National Grid Network before being transformed **down** for local and area distribution.

At this point in the Syllabus, the City & Guilds asks us to consider transmission and distribution of electricity. Please answer the following questions in the spaces provided.

1. The super-grid voltage is ....
2. The grid voltage is ....
3. Distribution voltage at local sub-stations to consumers is ....

....

6-234

4. In the space below use a sketch to show how a 400V three-phase supply and a 230V single-phase supply are connected to an 11 kV sub-station transformer.

5. When we talk about "balancing" loads, what do we mean?

   Balancing loads means..

   ....

   ....

Further information can be found on pages 182 to 187 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Wiring systems and enclosures

When we are designing an electrical installation we have a choice of wiring systems and enclosures to choose from. Part 5 of the IEE Regulations (BS 7671) deal with the selection and erection of equipment. The wiring system and enclosures chosen for the particular installation must take account of the installed conditions (IEE Regulation 522). In the spaces provided below state the advantages and limitations of some common wiring systems and enclosures.

Type (and small sketch)	**Advantages**	**Limitations or disadvantages**
MIMS		
PVC/SWA cable		
PVC single core cable		
PVC twin and earth cable		
Fire retardant cable		

Wiring enclosures

Type (and small sketch)	Advantages	Limitations or disadvantages
PVC and steel conduit		
PVC and steel trunking		
Cable tray and ladder		
Ducting systems		

Further information can be found on pages 193 to 213 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Conduit capacities

Single PVC insulated conductors are usually drawn into conduits to complete the installation of a conduit wiring.

The number of conductors which may be drawn into a conduit is restricted by a "factor system" to be found in the IEE Regulations (BS 7671).

Printed overpage at Table 6.1 are the cable factors and at Table 6.2 the conduit factors. Use these tables to answer the following questions. Show all your working out.

1. It is proposed to run **six** 2.5 mm cables and **one** 4 mm cable in PVC conduit which has **one** bend between boxes 6 m apart. Confirm that 20 mm conduit is suitable to contain these cables in these conditions.

2. Calculate the maximum number of 1 mm cables which may be drawn into a straight piece of 20 mm conduit 9 m in length.

3. Calculate the maximum number of 1 mm cables which may be drawn into a 9 m length of 20 mm conduit having **one** bend.

4. Calculate the maximum number of 1 mm cables which may be drawn into a 9 m length of 20 mm conduit having **two** bends.

Table 6.1 Cable factors for use in conduit in long straight runs over 3 m, or runs of any length incorporating bends. Adapted from the IEE *On Site Guide* by kind permission of the Institution of Electrical Engineers

Type of conductor	Conductor cross-sectional area (mm^2)	Cable factor
Solid or stranded	1	16
	1.5	22
	2.5	30
	4	43
	6	58
	10	105
	16	145
	25	217

The inner radius of a conduit bend should be not less than 2.5 times the outside diameter of the conduit.

Further information can be found on pages 202 to 205 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Table 6.2 Conduit cable factors for bends and long straight runs. Adapted from the IEE *On Site Guide* by kind permission of the Institution of Electrical Engineers

Table 5D
Cable factors for runs incorporating bends and long straight runs

Length of runs (m)	Conduit diameter (mm)																			
	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32
	Straight				One bend				Two bends				Three bends				Four bends			
1	Covered by				188	303	543	947	177	286	514	900	158	256	463	818	130	213	388	692
1.5					182	294	528	923	167	270	487	857	143	233	422	750	111	182	333	600
2	Tables				177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529
2.5					171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474
3	A and B				167	270	487	857	143	233	422	750	111	182	333	600				
3.5	179	290	521	911	162	263	475	837	136	222	404	720	103	169	311	563				
4	177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529				
4.5	174	282	507	889	154	250	452	800	125	204	373	667	91	149	275	500				
5	171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474				
6	167	270	487	857	143	233	422	750	111	182	333	600								
7	162	263	475	837	136	222	404	720	103	169	311	563								
8	158	256	463	818	130	213	388	692	97	159	292	529								
9	154	250	452	800	125	204	373	667	91	149	275	500								
10	150	244	442	783	120	196	358	643	86	141	260	474								

Additional factors: For 38 mm diameter use…1.4 × (32 mm factor)
For 50 mm diameter use…2.6 × (32 mm factor)
For 63 mm diameter use…4.2 × (32 mm factor)

System earthing arrangements

Sketch and briefly describe the system earthing arrangements for the types of supply indicated below.

TT system

TN-S system

TNC-S system

TN-C system

Further information can be found on pages 278 to 282 of *Advanced Electrical Installation Work* 5th Edition and Part 2 of the IEE Regulations (BS 7671).

Inspection and testing

All new installations must be inspected and tested during erection and/or on completion before being put into service and all existing installations must be periodically inspected and tested in order to ensure that they are safe and meet the current requirements of Part 6 of the IEE Regulations (BS 7671).

The frequency of inspection and testing is determined by the type of installation, its use and operation, the frequency of maintenance and the external influences to which it is subjected. The maximum period between testing and inspections is given in the IEE Guidance Note 3 (GN3) as follows:

General installations	
Domestic premises – at change of occupancy or	10 years
Commercial premises – at change of occupancy or	5 years
Educational premises	5 years
Hospitals	5 years
Offices, shops and laboratories	5 years
Buildings open to the public	
Churches	5 years
Restaurants and hotels	5 years
Public houses	5 years
Village halls	5 years
Theatres and place of public entertainment	3 years
Special installations	
Highway power supplies	6 years
Agricultural and horticultural	3 years
Caravans	3 years
Caravan Parks	1 year
Marinas, fish farms	1 year
Swimming pools	1 year
Petrol filling stations	1 year
Construction sites	3 months

The inspection process

The requirements of the IEE Regulations (BS 7671) with regard to the inspection process described in Section 611 are:

- That inspection shall precede testing.
- That inspection shall normally be done with that part of the installation under inspection disconnected from the supply.
- That inspection shall comprise careful scrutiny of the installation without dismantling, or with partial dismantling as required.
- The scope, range or extent of the inspection must be decided by a competent person after taking into account the availability of records and the use, condition and nature of the installation.
- Consultation with the client or the client's representatives before the inspection takes place is essential to determine the degree of disconnection which will be acceptable.
- For safety, it is necessary to carry out a visual inspection of the installation before testing, opening enclosures or removing covers.
- All electrical equipment must be visually inspected and the internal condition of a sample ascertained.
- The inspection must include a check on the condition of electrical equipment with regard to signs of:
  - wear and tear
  - corrosion
  - damage
  - excessive loading (overloading).
- Electrical equipment must also be checked for its:
  - safety
  - age
  - suitability
  - condition.

Periodic inspection

IEE Regulations (BS 7671) tell us at 621.2 that periodic inspection, comprising careful scrutiny of the installation shall be carried out without dismantling or with partial dismantling as required. This is supplemented by testing to verify compliance with the Regulations.

GN3 makes the following comments on individual items to be inspected.

Joints and connections: It is not possible or expected that every joint and termination be inspected. However, a sample should be made of switchgear, distribution boards, luminaire points and socket outlets.

Conductors: A sample should be taken of the condition of conductors at switchgear, distribution boards, luminaire and socket outlets. There should be no signs of overheating, overloading or damage to the insulation, armour sheath or conductors.

Flexible cables and cords: It should be examined for damage or defects, particularly at terminations and anchorage points. Checks should be made with regard to correctness of installation with regard to additional mechanical protection or heat resistant sleeving protection.

Accessories and switchgear: It is recommended that a random sample of about 10% of all accessories and switchgear be given a thorough internal visual inspection to assess their electrical and mechanical condition. Where the inspection reveals adverse conditions such as ingress of water, worn or damaged mechanisms, the inspection should be extended to every switching device.

Protection against thermal effects: The presence of fire barriers and seals should be verified.

Method of protection against electric shock: The requirements of Chapter 41 need to be verified.

The fundamental rule of protection against electric shock is that

- hazardous live parts shall not be accessible and
- accessible conductive parts (i.e. metalwork) shall not become hazardous live either in normal use or under fault conditions
- **basic protection** gives protection in normal or fault free conditions and **fault protection** gives protection under fault conditions.

Basic protection: Basic protection is provided by insulation of live parts or by barriers or by enclosures. It should be established that there has been no deterioration or damage to insulation, no removal of barriers and no alterations to enclosures or access to live parts which would reduce its effectiveness.

Fault protection: Fault protection is provided by protective earthing, protective equipotential bonding and automatic disconnection of the supply in the case of a fault.

The presence of earthing conductors, circuit protective conductors (CPCs), protective equipotential bonding conductors and supplementary bonding conductors must be verified.

Protective devices: It should be established that each circuit is protected with the correct sized rating and type of protective device. That each isolating and protective device is readily accessible and suitably labelled. That a means of emergency switching is provided.

Enclosures and mechanical protection: The enclosures of electrical equipment should be inspected to ensure that they remain adequate for the type of protection intended. That is, to prevent direct contact with live parts or the ingress of moisture.

Marking and labelling: It should be established that adjacent to every protective device and switching device, there is a label correctly indicating the size, type and protected circuit. At the origin of every installation there must be a notice stating "This installation must be periodically inspected and tested", etc. Earthing and bonding connections must display a sign "Safety Electrical Connection – Do Not Remove".

External influences: Note should be made of any known changes which may have affected the suitability of the wiring for its present load and method of installation.

Note should be made of any alterations or additions of any irregular nature to the installation together with any evidence of faulty workmanship or design.

The inspection process

Handouts 4 and 5 of this Unit deal with the inspection process. The IEE Wiring Regulations (BS 7671) at Chapter 61 also deals with the inspection process.

Read Handouts 4 and 5 and Section 611.3 of the Regulations and then list below about **twenty** important individual items to look for as a part of the inspection of an electrical installation:

1. ....
2. ....
3. ....
4. ....
5. ....
6. ....
7. ....
8. ....
9. ....
10. ....
11. ....
12. ....
13. ....
14. ....
15. ....
16. ....
17. ....
18. ....
19. ....
20. ....

The testing process

The testing of an installation implies the use of an instrument to obtain a reading. The results of the test must be compared with "relevant criteria" to determine if the readings are satisfactory or not (IEE Regulation 612.1).

The tests required by Regulations 612.2 to 612.6 must be carried out in that order before the installation is energized so that safety systems are tested first.

If any test indicates a failure to comply, then that test and any preceding tests must be repeated after the fault has been rectified because the results of the preceding tests may have been influenced by the fault.

Not all of the tests may be relevant to a "normal" electrical installation, for example test 612.5 will not be relevant to most domestic, commercial or light industrial applications.

The Regulations are listed quite clearly in Part 6 of the IEE Regulations (BS 7671) and described in the IEE GN3 as follows.

With the supply disconnected

With the supply disconnected or before the supply is energized, the following tests must be carried out on an electrical installation where they are relevant.

1. **(612.2.1) Continuity of protective conductors (CPCs):** These include the main equipotential and supplementary bonding conductors. Resistance values should be in the order of 0.05 Ω or less (GN3, 3.10.3).

2. **(612.2.2) Continuity of ring final circuit conductors:** The test verifies the continuity of each conductor including the protective conductors and the "ringness" of the ring, that is that there are no interconnections or breaks.

3. **(612.3) Insulation resistance:** The minimum requirement is 1.0 MΩ but values of less than 2 MΩ require further investigation and each circuit should be tested separately.

4. **(612.4) Protection by SELV, PELV or electrical separation**
5. **(612.5) Insulation resistance/impedance of floors and walls**

Tests not usually required

6. **(612.6) Polarity:** The objective is to verify that all fuses, circuit breakers and switches are connected in the line conductor.

7. **(612.7) Earth electrode resistance:** If the electrode (spike) under test is being used in conjunction with a residual current device (RCD) protected TT installation, the electrode must be disconnected at the main earthing terminal for the duration of the test, leaving the installation unprotected. Therefore, switch off the supply before disconnecting the earth. Table 2.3 of GN3 gives maximum values but in practice, values above 200 Ω for a TT installation will require further investigation.

8. **The electrical supply may now be connected or reconnected**

   At this point the polarity should be confirmed before further testing is carried out. Using an approved voltage indicator and probes which comply with HSE 9.5.38 (IEE Guidance Note 3, 2.7.12).

9. **(612.9) Earth fault loop impedance Zs**: The whole earth fault current loop is examined by this test.

   The test will, in most cases, be done with a purpose-built line earth loop impedance tester. The test is carried out with the supply switched on from the furthest point of every final circuit.

   Purpose-built testers give a read-out in ohms and a satisfactory result is indicated when the earth loop impedance does not exceed the values given in Table 41.2 and 41.3 of the IEE Regulations.

10. **(612.10) Additional protection:** Where RCDs are required for additional protection, the effectiveness of the disconnection of supply by the RCD shall be verified by visual inspection and test.

    Purpose built test instruments give a read-out in milliseconds and are used to prove the requirements of, for example, IEE Regulation 415 which requires a 30 mA RCD to operate in a time not exceeding 40 ms.

11. **(612.11) Prospective fault current:** The prospective fault current under both short-circuit and earth fault conditions must be ascertained by enquiry or verified by measurement or calculation. The breaking capacity of the protective device must be greater than the prospective fault current at that point in the installation.

    The rated short-circuit capacities of fuses and circuit breakers are shown in Table 2.4 of the IEE Regulations GN3.

12. **(612.12) Check of phase sequence**: For three-phase circuits the brown, black, grey phase sequence must be verified.

13. **(612.13) Functional tests:** Functional testing means that devices are operated to confirm that they work and are properly installed, mounted or adjusted. The integral test device marked T or Test incorporated in RCDs should be operated to prove the mechanical parts of the RCD. However, this does not test the effectiveness of the RCD. To do this will require an RCD test as described above in "Additional protection".

Electrical test instruments

Electrical installation testing in accordance with the IEE Regulations (BS 7671) demands the use of specialist test instruments.

It is unacceptable for a professional electrician to carry out electrical testing using instruments bought at the local DIY Superstore unless they carry a calibration certificate, are manufactured to the appropriate British Standard and meet the specification requirements of the IEE Regulations (BS 7671), Section 612.

A full set of test instruments will cost in the region of £1000. They must be protected in a suitable case, handled carefully and provided with security. They represent a considerable investment for your company.

The basic instrument standard is BSEN 61557. The safety measures set out in the HSE Guidance Note GS 38 should also be observed for the instrument, leads, probes and accessories (Fig. 6.1).

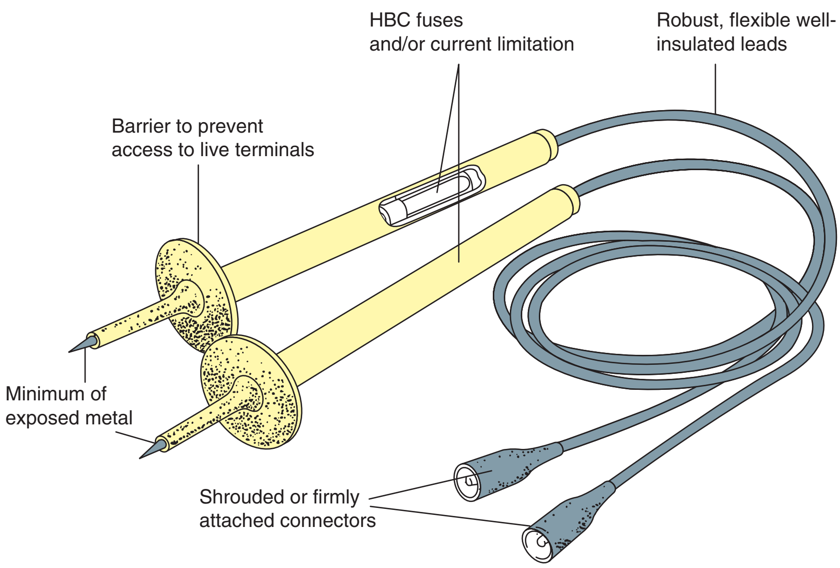


FIGURE 6.1
Recommended type of test probe and leads.

Instrument accuracy

The basic measurement accuracy required of these instruments is 5% and it is assumed that measurements taken in the field will be as good as this that is 95% accurate. Actual reading accuracy will be affected by the operator's ability, battery, condition, and the orientation of the test instrument.

Calibration

Instruments must be regularly calibrated to maintain their accuracy. The standards used in the re-calibration must be traceable to the National Standards and should be checked after any mechanical or electrical mis-handling or at least yearly.

Low-resistance ohmmeter specification

The instrument used for low-resistance tests may be either a low-resistance ohmmeter or the continuity range of an insulation and continuity tester. The test current may be d.c. or a.c. and it is recommended that it be derived from a source with no-load voltages between 4 and 24V and a short-circuit current not less than 200 mA.

The measuring range should cover the span 0.2–2 Ω with a resolution (separation of marks) of at least 0.01 Ω for digital instruments.

Factors affecting accuracy

Contact resistance where the crocodile clips make contact, and lead resistance. Make sure connections are good and measure and subtract the lead resistance from the final value.

Insulation-resistance ohmmeter specification

The instrument must be capable of developing the test voltage required across the load. 500V d.c. for 230 and 400V installations.

The tester must be capable of supplying an output current of 1 mA at the required test voltage.

Factors affecting accuracy

A 50 Hz current is induced into the cables under test and capacitance in the test object may be as high as 5 μF. These errors cannot be eliminated but a BSEN Standard instrument will have an automatic discharge facility. Following the test, the instrument should remain connected until the capacitance within the installation has fully discharged.

Earth fault loop impedance tester specification

These instruments work by circulating a current into the protective earth which may cause a voltage rise in the protective conductor during the test. To minimize the electric shock hazard, the instrument must cut off after 40 ms or, if the voltage rise of the protective conductor exceeds 50V, during the test.

Factors affecting accuracy

The instrument uses the mains supply and transient (passing quickly) variations of the mains voltage during the test period may cause errors. To allow for the effects of transient voltages, the test should be repeated at least once.

RCD tester specification

The test instrument must simulate a fault and measure the time taken for the RCD to operate. A few milliamperes are required to operate the test instrument and this is obtained from the line and neutral of the circuit under test. The test instrument must be capable of supplying the full range of RCD currents.

Factors affecting accuracy

Transient variations of the mains voltage during the test period may cause errors.

To minimize danger during the test, the test current should be applied for no longer than 2 s.

Instruments conforming to BSEN 61557 will fulfil these requirements.

Certification and reporting

The reasons for certification:

- All electrical equipment deteriorates with age and wear and tear from use.
- Every electrical installation, therefore, needs to be tested and inspected periodically during its lifetime to establish that its condition is such that it is safe to remain in service at least until the next inspection is due.
- To provide a record of the condition of a new installation.
- To provide a record of the condition of an altered or extended installation.

There are **three** types of certificate available:

1. **Electrical installation certificates:** For new installations or for alterations or additions to existing installations where new circuits have been introduced.

2. **Periodic inspection reports:** For reporting the condition of an existing installation.

3. **Minor electrical installation works certificate:** For additions to an electrical installation that do not extend to the introduction of a new circuit, for example the addition of a socket outlet or lighting point to an existing circuit (IEE Regulations 631.3):
   - Correctly completed certificates provide the person responsible for the safety of the electrical installation with an important record of the condition of the installation at the time it was inspected and tested.
   - Certificates and reports provide the basis for subsequent inspection and testing without which, a degree of costly exploratory work may be required.
   - In the event of an injury or fire occurring, allegedly as a result of an electrical fault, the certificates and reports will provide documentary evidence to help demonstrate that the installation was installed and subsequently maintained to a satisfactory standard of safety.
   - Electrical contractors approved by the NICEIC must issue the NICEIC “red” certificates and report forms. Non-approved contractors are not authorized to use the “red” forms. However, forms can be found in the IEE Regulations (BS 7671) in Appendix 6.

Electrical installation testing

For each test listed below, state the reason for the test, the type of instrument you would use for the test and the results of an acceptable test.

Type of test – Continuity of protective conductors (IEE Regulation 612.2.1)

The reason for carrying out the test ....

....

The type of instrument to be used ....

....

The result of a satisfactory test ....

....

....

Type of test – Continuity of ring final circuit conductors (IEE Regulation 612.2.2)

The reasons for carrying out the test ....

....

The type of instrument to be used ....

....

The result of a satisfactory test ....

....

....

Type of test – Insulation resistance (IEE Regulation 612.3)

The reasons for carrying out the test ....

....

The type of instrument to be used ....

....

The result of a satisfactory test ....

....

....

Type of test – Polarity (IEE Regulation 612.6)

The reasons for carrying out the test ....

....

The type of instrument to be used ....

....

The result of a satisfactory test ....

....

....

Further information can be found in Handouts 6 and 7 of this unit and on pages 321 to 326 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Electrical installation test procedures

Use the information given in Handouts 6 and 7 and the IEE GN3 Section 2.7 or other sources as directed by your Lecturer to describe (briefly) how you would carry out the following tests.

Test (612.2.1) Continuity of protective conductors

How to carry out the test:

....

....

....

....

....

....

Test (612.2.2) Continuity of ring final circuit conductors

How to carry out the test:

....

....

....

....

....

....

Test (612.3) Insulation resistance

How to carry out the test:

....

....

....

....

....

....

Test (612.6) Polarity with the supply disconnected

How to carry out the test:

....

....

....

....

....

....

Test (612.6) Polarity with the supply connected (IEE Guidance Note 3)

How to carry out the test:

....

....

....

....

....

....

Test (612.13) Functional tests of RCDs

How to carry out the test:

....

....

....

....

....

....

Further information can be found on pages 321 to 330 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Selecting electrical test instruments

For each of the instruments below, identify what they would be suitable for testing and how they would be connected into a circuit for the test.

Multimeters **What do they test?**

....

How would they be connected into a circuit for the test? (Use a sketch if this is helpful.)

Wattmeters **What do they test?**

. . . .

How would they be connected into a circuit for the test? (Use a sketch.)

Tong testers **What do they test?**

. . . .

How would they be connected into a circuit for the test? (Use a sketch.)

Earth loop impedance testers **What do they test?**

....

How would they be connected into a circuit for the test? (Use a sketch.)

Low-ohm continuity testers **What do they test?**

....

How would they be connected into a circuit for the test? (Use a sketch.)

Further information can be found on pages 310 to 312 of *Advanced Electrical Installation Work* 5th Edition ISBN 9780750687522 and IEE Guidance Note 3.

Inspection testing and certifying: A summary worksheet

Answer the questions below in the space provided.

1. State when the formal "inspection" of an electrical installation would normally take place and the reasons for carrying out the inspection.

   The inspection normally takes place ....

   ....

   The reason for the inspection is ....

   ....

2. Why do we carry out electrical testing of an electrical installation?

   Electrical testing is carried out to ....

   ....

3. What action must be taken if the test result of one of the tests recommended by the IEE Regulations fails to comply with the Regulations?

   If any test proves unsatisfactory ....

   ....

4. The IEE Regulations recommend a maximum frequency of periodic inspecting and testing of electrical installations. State the type of installations which fall into the following inspection and testing periods.

   10 years inspections and testing – ***for example domestic premises***

   5 years inspections and testing..

   3 years inspections and testing..

   1 year inspections and testing..

   3 months inspections and testing..

5. The IEE Regulations specify **three** types of certificate to be issued following the inspection and testing process and on completion of the work done. Identify where each type of certificate should be issued.

An Electrical Installation Certificate...

....

....

A Periodic Inspection Report...

....

....

Minor Electrical Installation Works Certificate..

....

....

6. What is the importance of "documentary evidence" relating to electrical installations such as Electrical Certificates?

Electrical installation Certificates and Reports are important because ....

....

....

....

7. State the importance of "regular calibration" of the test instruments used in the inspection and testing process?

Regular calibration of test instruments is important because.......................................

....

....

....

8. State the importance of verifying or checking test instruments and voltage indicators.

....

....

....

....

9. Who would carry out the "inspection and testing" of a new electrical installation completed by the Company you work for?

His name ....**His title**.......................................

Why does the person named above carry out the important task of inspecting and testing electrical installations and completing the necessary Test Certificate and Reports for the Company you work for instead of, say the apprentice? ....

....

....

....

10. The type of test instrument and test leads used in the inspection and testing process must comply with **three** important standards. These are:

BS.................................**BS EN**................................ **GS** ....

Where should you, or the Company you work for, purchase electrical test instruments from?

....

....

....

Further information can be found in Handouts 3, 5, 7 and 8 and Chapter 8 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Note: Please note that more than one answer may be correct.

1. **The person or group of people responsible for ordering and financing a construction project is called the:**
   a. architect ☐
   b. client ☐
   c. sub-contractor ☐
   d. quantity surveyor. ☐

2. **The leader of the construction team and the person responsible for interpreting the customer's requirements and producing working drawings is called the:**
   a. architect ☐
   b. client ☐
   c. sub-contractor ☐
   d. quantity surveyor. ☐

3. **The person measuring the amounts of labour and materials required for the construction project is called the:**
   a. architect ☐
   b. client ☐
   c. sub-contractor ☐
   d. quantity surveyor. ☐

4. **If the builder on a construction project is the main contractor, the electrical installation company is called the:**
   a. architect ☐
   b. client ☐
   c. sub-contractor ☐
   d. quantity surveyor. ☐

5. **The management systems and procedure which identifies the activities taking the longest time required to complete the whole contract is called a:**
   a. bar chart ☐
   b. critical path network analysis ☐
   c. site diary ☐
   d. variation order. ☐

6. **The management systems and procedure which identifies work done on site which is outside the scope of the original contract is called a:**
   a. bar chart ☐
   b. critical path network analysis ☐
   c. site diary ☐
   d. variation order. ☐

7. **The management systems and procedure which identifies the sequence and time taken for various activities taking place on site is called a:**
   a. bar chart ☐
   b. critical path network analysis ☐
   c. site diary ☐
   d. variation order. ☐

8. The management systems and procedure which records the daily events taking place on site is called a:

a. bar chart ☐
b. critical path network analysis ☐
c. site diary ☐
d. variation order. ☐

9. Area electricity distribution between counties has bare conductors suspended on steel suspension towers and takes place at a voltage of:

a. 230V ☐
b. 400V ☐
c. 11 kV ☐
d. 25 kV ☐
e. 33 kV ☐
f. 132kV ☐
g. 275 kV ☐
h. 400 kV ☐

(*Note*: more than one answer may be correct.)

10. Generation of electricity in a modern Power Station is at a voltage of:

a. 230V ☐
b. 400V ☐
c. 11 kV ☐
d. 25 kV ☐
e. 33 kV ☐
f. 132 kV ☐
g. 275 kV ☐
h. 400 kV ☐

(*Note*: more than one answer may be correct.)

11. Local sub-stations receive electricity at a voltage of:

a. 230V ☐
b. 400V ☐
c. 11 kV ☐
d. 25 kV ☐
e. 33 kV ☐
f. 132 kV ☐
g. 275 kV ☐
h. 400 kV ☐

(*Note*: more than one answer may be correct.)

12. Single-phase small domestic consumers take a supply at a voltage of:

a. 230V ☐
b. 400V ☐
c. 11 kV ☐
d. 25 kV ☐
e. 33 kV ☐
f. 132 kV ☐
g. 275 kV ☐
h. 400 kV ☐

(*Note*: more than one answer may be correct.)

13. Three-phase small industrial consumers take a supply at a voltage of:

a. 230V ☐
b. 400V ☐
c. 11 kV ☐
d. 25 kV ☐
e. 33 kV ☐
f. 132 kV ☐
g. 275 kV ☐
h. 400 kV ☐

(*Note*: more than one answer may be correct.)

14. Transmission on the electricity super-grid is at a voltage of:

a. 230V ☐
b. 400V ☐
c. 11 kV ☐
d. 25 kV ☐
e. 33 kV ☐
f. 132 kV ☐
g. 275 kV ☐
h. 400 kV ☐

(*Note*: more than one answer may be correct.)

15. PVC twin and earth cable wiring systems are:

a. conduit installations ☐
b. cheap and easy to use and install ☐
c. fireproof installations ☐
d. mechanical protection for the cable conductors. ☐

16. MIMS cable wiring systems are suitable for:

a. conduit installations ☐
b. cheap and easy to use and install ☐
c. fireproof installations ☐
d. mechanical protection for the cable conductors. ☐

17. A PVC/SWA cable wiring system provides:

a. conduit installations ☐
b. cheap and easy to use and install ☐
c. fireproof installations ☐
d. mechanical protection for the cable conductors. ☐

18. PVC single core cable wiring systems are suitable for use with:

a. conduit installations ☐
b. cheap and easy to use and install ☐
c. fireproof installations ☐
d. mechanical protection for the cable conductors. ☐

19. A tube made of steel or PVC containing PVC single core cables is one description of:

a. conduit ☐
b. ducting ☐
c. tray ☐
d. trunking. ☐

20. A rectangular or square steel section containing conductors is one description of:
a. conduit ☐
b. ducting ☐
c. tray ☐
d. trunking. ☐

21. Galvanized sheet steel channel with multiple holes upon which is secured cables is one description of:
a. conduit ☐
b. ducting ☐
c. tray ☐
d. trunking. ☐

22. An underground or vertical channel suitable for cables or busbars is one description of:
a. conduit ☐
b. ducting ☐
c. tray ☐
d. trunking. ☐

23. One of the most common types of low-voltage supply system to be found in the UK where the electricity supply companies cables are run underground to the consumer are called a:
a. TT system ☐
b. TN-C system ☐
c. TN-S system ☐
d. TN-C-S system. ☐

24. An increasingly popular low-voltage supply system commonly referred to as protective multiple earthing (PME) using a combined protective conductor and neutral conductor is called a:
a. TT system ☐
b. TN-C system ☐
c. TN-S system ☐
d. TN-C-S system. ☐

25. The low-voltage supply system is fed from overhead cables. The supply authorities do not provide an earth terminal and the installation's circuit protective conductors must be connected to earth via an earth electrode. This type of supply system is called a:
a. TT system ☐
b. TN-C system ☐
c. TN-S system ☐
d. TN-C-S system. ☐

26. All electrical installations must be periodically inspected and tested. A Church should be inspected and tested every:
a. 3 months ☐
b. 1 year ☐
c. 3 years ☐
d. 5 years. ☐

27. Commercial greenhouses should be inspected and tested every:
a. 3 months ☐
b. 1 year ☐
c. 3 years ☐
d. 5 years. ☐

28. Construction sites should be inspected and tested every:
a. 3 months ☐
b. 1 year ☐
c. 3 years ☐
d. 5 years. ☐

29. Caravan Parks should be inspected and tested every:
a. 3 months ☐
b. 1 year ☐
c. 3 years ☐
d. 5 years. ☐

30. Devices that are operated to confirm that they work and are properly installed is one description of:
a. electrical installation inspection ☐
b. electrical installation testing ☐
c. commissioning ☐
d. functional testing. ☐

31. The process implies the use of an instrument to obtain readings and is one description of:
a. electrical installation inspection ☐
b. electrical installation testing ☐
c. commissioning ☐
d. functional testing. ☐

32. "Shall comprise careful scrutiny of the installation without dismantling" is one description of:
a. electrical installation inspection ☐
b. electrical installation testing ☐
c. commissioning ☐
d. functional testing. ☐

33. The test required by the IEE Regulations to ensure that the CPCs including the protective equipotential and supplementary bonding conductors are correctly connected, electrically sound and have a very low resistance is called:
a. continuity of protective conductors ☐
b. continuity of ring final circuit conductors ☐
c. insulation resistance ☐
d. site applied insulation. ☐

34. The test required by the IEE Regulations to ensure that the quality of cable insulation is satisfactory is:
a. continuity of protective conductors ☐
b. continuity of ring final circuit conductors ☐
c. insulation resistance ☐
d. site applied insulation. ☐

35. The instrument required to carry out the CPCs test on a 230V domestic installation is:
a. 250V insulation resistance ohmmeter ☐
b. 500V insulation resistance ohmmeter ☐
c. insulation and continuity ohmmeter set to the continuity range ☐
d. earth loop impedance tester. ☐

36. The instrument required to carry out the continuity of ring final circuit conductors test on a 230V domestic installation is:
a. 250V insulation resistance ohmmeter ☐
b. 500V insulation resistance ohmmeter ☐
c. insulation and continuity ohmmeter set to the continuity range ☐
d. earth loop impedance tester. ☐

37. The instrument required to carry out the insulation resistance test on a 230V installation is:
a. 250V insulation resistance ohmmeter ☐
b. 500V insulation resistance ohmmeter ☐
c. insulation and continuity ohmmeter set to the continuity range ☐
d. earth loop impedance tester. ☐

38. An acceptable test result for a CPCs test is:
a. approximately 0.05 Ω ☐
b. less than 200 Ω ☐
c. less than 0.5 MΩ ☐
d. greater than 1.0 MΩ. ☐

39. An acceptable test result for an insulation resistance test is:
a. approximately 0.05 Ω ☐
b. less than 200 Ω ☐
c. less than 0.5 Ω ☐
d. greater than 1.0 MΩ. ☐

40. An acceptable test result for an earth electrode resistance test on a TT installation is:
a. approximately 0.05 Ω ☐
b. less than 200 Ω ☐
c. less than 0.5 Ω ☐
d. greater than 1.0 MΩ. ☐

41. One objective of the polarity test is to verify that:
a. the CPC is continuous throughout the installation ☐
b. landholders and switches are earthed ☐
c. final circuits are fused ☐
d. protective devices are connected in the live conductor. ☐

42. The closeness of the test instrument's reading to the true value is one definition of:
a. crocodile clip contact resistance ☐
b. instrument calibration ☐
c. instrument accuracy ☐
d. electrical testing. ☐

43. The factors that might affect the accuracy of the test instrument readings are:
a. the competence of the tester ☐
b. the resistance of the circuit under test ☐
c. the contact resistance of the test leads ☐
d. the state of charge of the instrument batteries. ☐

44. To maintain the accuracy of any electrical test instrument it must be:

a. treated with care ☐
b. regularly certificated ☐
c. regularly calibrated ☐
d. used regularly. ☐

45. Test instrument leads must be robust, have finger barriers and comply with:

a. IEE Regulation BS 7671 ☐
b. HSE Guidance Note GS 38 ☐
c. British Standard BSEN 61557 ☐
d. On Site Guide Section 10 "Safety and Equipment". ☐

46. Following the inspection and testing of an electrical installation the correct certificates would be completed and verified by signing by:

a. the Managing Director of the Electrical Company ☐
b. the most senior supervisor of the Company ☐
c. the most senior apprentice ☐
d. any "competent" person. ☐

47. What action must be taken if the test results of one of the tests recommended by the IEE Regulations fail to comply with the Regulations?

a. stop all further testing ☐
b. stop all further testing until the fault is rectified ☐
c. rectify the fault and carry on with the series of tests ☐
d. rectify the fault and repeat that test and all preceding tests. ☐

48. An Electrical Installation Certificate should be issued to the client following the inspection and testing of:

a. any existing electrical installation ☐
b. any industrial or commercial work but not domestic installations ☐
c. any new installation or for alterations or additions where new circuits have been added ☐
d. any alterations or additions that do not extend to the introduction of a new circuit. ☐

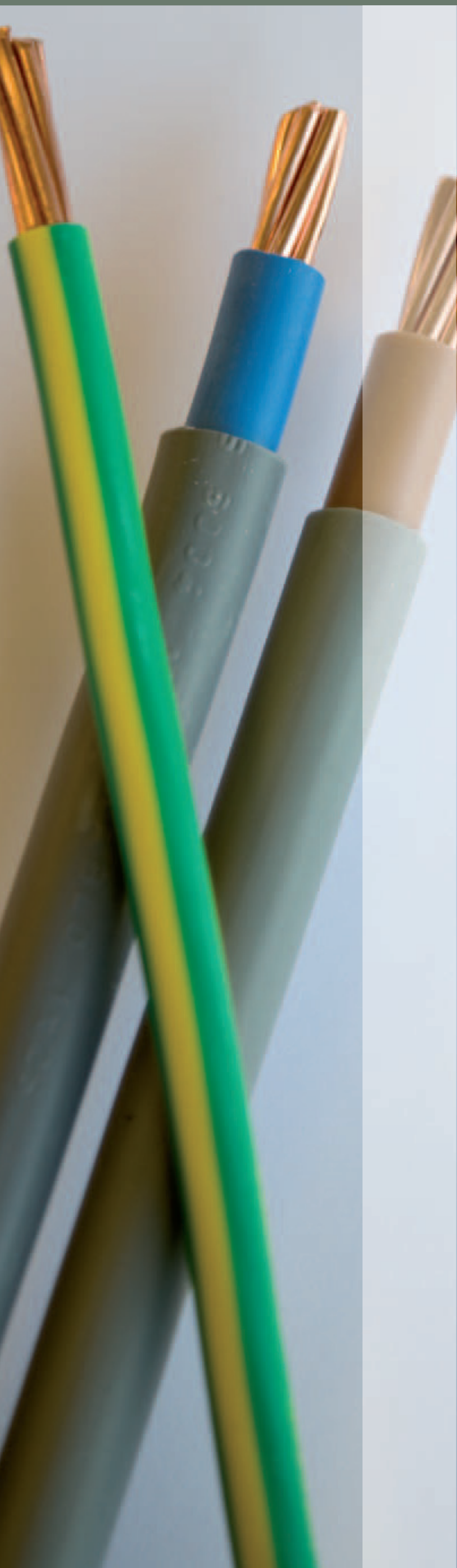
49. Periodic Inspection Reports should be issued to the customer following the inspection and testing of:

a. any existing electrical installation ☐
b. any industrial or commercial work but not domestic installations ☐
c. any new installation or for alterations or additions where new circuits have been added ☐
d. any alterations or additions that do not extend to the introduction of a new circuit. ☐

50. A Minor Electrical Installation Works Certificate should be issued to the client following inspection and testing of:

a. any existing electrical installation ☐
b. any industrial or commercial work but not domestic installations ☐
c. any new installation or for alterations or additions where new circuits have been added ☐
d. any alterations or additions that do not extend to the introduction of a new circuit. ☐

Answers to Worksheets 1 to 14



Worksheet 1

1. The client is the person ordering the work and will finance the whole project.
2. The main contractor will enter into a contract with the client to carry out the whole project. This is usually the building company.
3. Sub-contractors may be engaged by the main contractor to carry out specialist work such as the electrical installation.
4. Suppliers provide the main contractor and sub-contractors with the materials to be used in the project – bricks and block for the building contractor, conduit, cable and accessories for the electrical contractor, etc.
5. Consultants provide specialist services, usually to the Architect. They might be Quantity Surveyors calculating bills of quantities or Structural Engineers calculating the size of steel girders to support the proposed building.

Worksheet 2

Answers at the discretion of the Lecturer.

(a) The Building Regulations lay down the design and build standards for construction work. The scope of the Regulations range from structures to fire safety, ventilation, hygiene, drainage and glazing safety. They will influence the work of the building team.

(b) Environmental Regulations set the standards for the control of pollution to land, air and water. So, drainage from a new building (i.e. waste products from toilets and rainwater) must comply with Parts D, G and H of the Building Regulations. Noise Regulations control noise or vibrations from a building. Thus, noisy extractor fans or refrigeration fans on the outside of a commercial building may contravene the Regulations. These Regulations will influence the work of the building team, the plumbing contractor and the heat and ventilation contractor. The Controlled Waste Regulations will affect everyone on site.

(c) The Health and Safety at Work Regulations are probably the most powerful and far reaching of all modern regulations. They control our working environment from personal protective equipment (PPE) and working at heights to ensuring that plant and equipment is properly maintained and "*any other risks which are particular to a specific type of work*". How about that for a bold statement in the Act! These Regulations will influence everyone on site.

(d) The IEE Regulations (BS 7671) are the Electricians' Bible. If the electrical installation meets the modern requirements of the IEE Regulations it will probably meet all other relevant electrical regulations. For an electrical contractor, there is only one standard to work to and that is the standard laid down by the IEE Regulations.

Worksheet 3

Answers at the discretion of the Lecturer.

Bar charts are a visual aid of the contracts progress. They show the sequence and time taken by each separate activity within the contract.

Critical path networks show the interrelationship of the various tasks in a contract. For example, some tasks must be completed before others can commence. The conduit must be erected before wiring can begin. The critical path is the longest time taken from the start event to the finish event. The path denotes the time taken for the whole contract and it is "critical" because any holdups on activities along the critical path will delay the completion of the contract.

Site diaries and site records are used on larger contracts. They are completed by the site supervisor or site foreman to record significant and relevant events on site. For example, how many people were working on site each day, what goods were delivered, records of site meetings and decisions taken at those meetings, holdups or time lost on site.

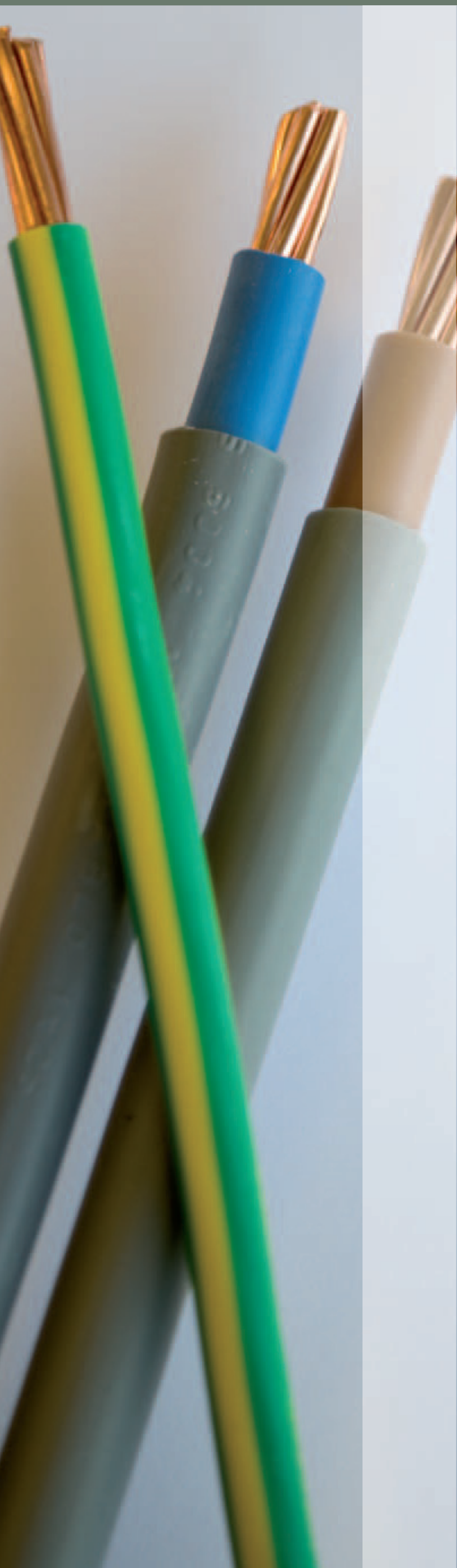
Some companies use two separate documents. The site diary records all daily events and remains on site for the duration of the contract, while the site record is a weekly report summarizing the daily events. This record is sent back to the office in order to inform management of progress being made.

A variation order describes a variation or change to the work agreed in the contract. Changing what was agreed to and "costed" for in the original contract costs time and money, so the person signing the variation order must have the authority to do so, for example the Architect or Clerk of Works.

Worksheet 4

Answers at the discretion of the Lecturer.

The Syllabus says the importance of "effective" communications is to maintain "good" relationships. Perhaps we need to look at this topic as electrical contractors and not as individuals, but representatives of the company. Therefore, I think that in most cases communications will be by letter, memo or fax for the attention of an individual, in order to maintain



the personal but professional approach. In the case of communications with colleagues and other trades, I think this will be verbal.

Worksheet 5

1. Super-grid at 275 kV and 400 kV
2. Grid at l32 kV
3. Local Subs at 11 kV and 33 kV
4. At Lecturer's discretion.
5. Distribution of single-phase loads across the three phases so that each phase carries approximately the same current.

Worksheet 6

Answers at Lecturer's discretion.

I think a simple thumbnail sketch would be informative for the individual students although not asked for in syllabus.

- MIMS: Very attractive cable suitable for most types of installation but expensive and terminations require considerable skill.
- PVC/SWA: Very robust cable with many industrial applications, easy to terminate successfully, not flameproof or heatproof like MIMS.
- PVC single core: Relatively inexpensive, industrial and commercial applications because must be installed in an enclosure of conduit or trunking.
- PVC twin and earth: Universal domestic applications, not flameproof or heatproof and may require additional mechanical protection.
- Fire retardant: Cable such as FP 200 has special heatproof qualities and, therefore, special applications. Very attractive, very easy to terminate but may require additional mechanical protection in some applications.
- PVC conduit: Very quick and easy installation, not as robust as steel.
- Steel conduit: Ideal industrial applications, special equipment required such as stocks, dies and bending machines.
- PVC trunking: Quick and easy installation, attractive commercial applications.
- Steel trunking: Ideal industrial applications especially when mixed with steel conduit – these are all expensive labour intensive installations.

- Cable tray and ladder: Ideal industrial applications for supporting MIMS or SWA cables. Additional cables may be added as industrial needs change and, therefore, a flexible system.
- Ducting: Underground, underfloor or rising mains has many commercial and industrial applications.

Worksheet 7

1. Sum of cable factors is 223. Conduit factor is 233, therefore, OK.
2. Conduit factor is 250. Each cable factor is 16, therefore, 15 conductors maximum.
3. Conduit factor is 204. Each cable factor is 16, therefore, 12 conductors maximum.
4. Conduit factor is 149. Each cable factor is 16, therefore, 9 conductors maximum.

Observation: number of bends restricts number of cables.

Worksheet 8

Answers at Lecturer's discretion.

The systems are shown at Part 2 of the IEE Regulations.

It may be worth noting that the TN-C system is not suitable for public supply. But is listed in the CGLI syllabus.

Worksheet 9

Answers at Lecturer's discretion.

I am trying here to reinforce the inspection process discussed in Handouts 4 and 5. The students will need access to Chapter 61 of the Regulations.

Worksheet 10

Some information given in Handouts 6 and 7 but answers at Lecturer's discretion.

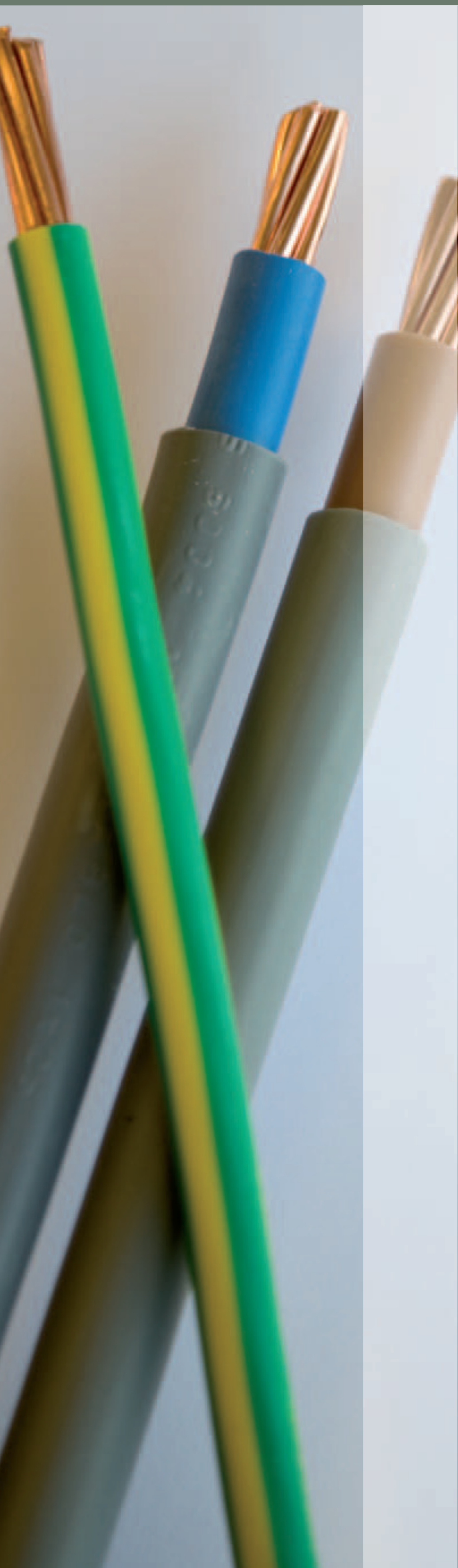
Worksheet 11

Some information given in Handouts 6 and 7 and GN3, but answers at Lecturer' discretion.

Worksheet 12

Answers at Lecturer's discretion.

- Multimeters test volts, amps and ohms. Connected in series as an ammeter and in parallel as a voltmeter. Not a suitable instrument



for insulation and continuity tests required by 612 of IEE Regulations.

- Wattmeters measure power in a.c. circuits. Usually four connections for current and voltage coils, connect in series and parallel.
- Tong tester clip on ammeter, works on transformer principle.
- Earth loop impedance tester measures earth fault loop impedance. Direct measurement of Zs can be made on live installations.
- Low-ohm continuity tester used to measure value of CPCs including protective equipotential and supplementary bonding. Instrument must be capable of measuring resistance values in the region of $0.05\,\Omega$ derived from an instrument source with no-load voltage between 4 and 24 V and short-circuit current not less than 200 mA. Multimeter unlikely to meet this test instrument specification defined in Section 4 of IEE Guidance Note 3.

Worksheet 13

Answers at Lecturer's discretion.

1. Takes place before testing as part of the inspection and testing procedure in order to verify safety and compliance with the Regulations.
2. To verify safety. To verify installation meets "relevant criteria". That is the IEE Regulations. To obtain test results. To obtain data to complete Certificate and Inspection and Test Result Schedules.
3. That test and preceding tests must be repeated after fault is rectified (612.1).
4. See Handout 3.
5. See Handout 8.
6. In this age of litigation they provide documented, auditable evidence that the installation meets the relevant safety criteria when completed. That the installation safety has been monitored over time (Periodic Inspections). Provides an on-going record of the condition/deterioration of the installation over time. Provides a record of being maintained to a standard of safety.
7. (a) To maintain the accuracy of the instrument.
   (b) To maintain the authenticity of the test results.
   (c) To maintain the authenticity of the Test Certificates.

8. To verify means to check the truth or correctness of – therefore, we must check or verify the accuracy of the Test Instruments by either connecting to a known source or supply or by comparing with a standard test instrument or source which is the process used when calibrating instruments. So always use calibrated instruments having an "in date" calibration certificate. Also voltage indicators such as the Martindale must be verified with a proving unit as a part of the secure isolation procedure.
9. Appendix 6 of the IEE Regulations state that the certification required by Part 6 of the IEE Regulations must be made out, signed and authenticated by a "competent person". The person signing the certificate has the experience or knowledge, has received the appropriate training or holds the relevant certificates, is the company's nominated person.
10. Test specification BS 7671 – instrument Standard BSEN 61557 and leads and probes standard HSE Guidance Note GS 38.

Instruments purchased from Wholesalers, Robin Instruments or any reliable source. New instruments should be purchased with calibration certificate.

Worksheet 14 (MC questions)

1 = b	**11 = c and e**	**21 = c**	**31 = b**	**41 = d**
2 = a	**12 = a**	**22 = b**	**32 = a**	**42 = c**
3 = d	**13 = b**	**23 = c**	**33 = a**	**43 = a, c and d**
4 = c	**14 = g and h**	**24 = d**	**34 = c**	**44 = a and c**
5 = b	**15 = b**	**25 = a**	**35 = c**	**45 = b and c**
6 = d	**16 = c**	**26 = d**	**36 = c**	**46 = d**
7 = a	**17 = d**	**27 = c**	**37 = b**	**47 = d**
8 = c	**18 = a**	**28 = a**	**38 = a**	**48 = c**
9 = f	**19 = a**	**29 = b**	**39 = d**	**49 = a**
10 = d	**20 = d**	**30 = d**	**40 = a and b**	**50 = d**

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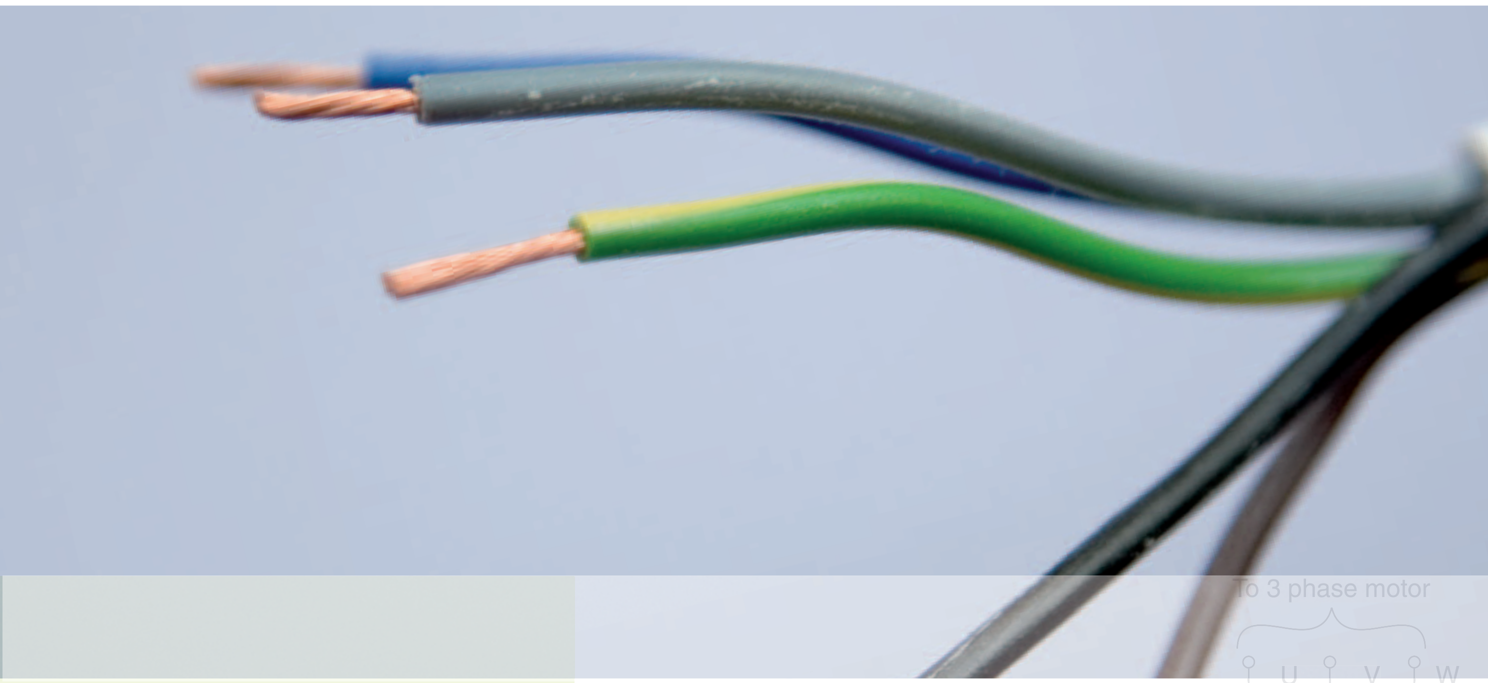
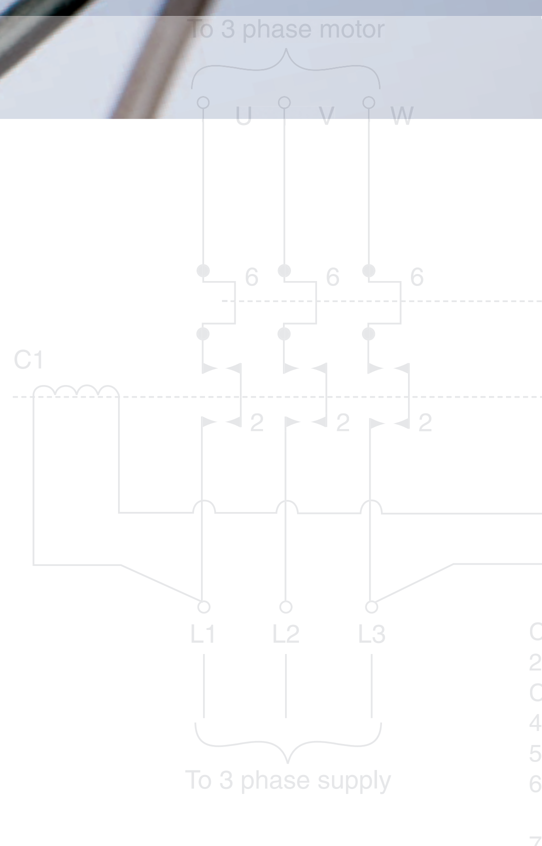
7

Unit 3, Level 3
Installation (Buildings and Structures)
Fault Diagnosis and Rectification





Level 3 – Certificate in Electrotechnical Technology

Contents

Safe working procedures before undertaking fault diagnosis

To diagnose (i.e. to determine the nature of) and to find faults in electrical installations, systems and equipment, is probably one of the most difficult tasks undertaken by any electrician because:

- we work on large and sometimes complex systems;
- no two faults are ever exactly the same;
- to be successful, an individual must have a thorough understanding and knowledge of the system or piece of equipment being investigated.

The ideal way to diagnose a fault is to follow a reasoned and logical approach, but also:

- gather information from documents and those around you who normally work on the systems or equipment;
- always proceed with caution and work safely, especially if the equipment or systems are electrically live;
- always know your own limitations – do you really have the skills and experience necessary to carry out this task successfully?

The Electricity at Work Act 1989 at Regulation 4(3) tells us that it is preferable that supplies be made dead before work commences. However, it also acknowledges that some work, such as fault diagnosis, may require that electrical equipment remains energized.

Where the systems or equipment remain energized during the fault diagnosis process, the person carrying out the work must:

- be aware of his own safety and that of others who might be affected by his actions;
- have a thorough understanding of the system or piece of equipment;
- be trained to carry out this type of work; and
- therefore be considered “competent” to carry out the fault diagnosis process.

While live fault diagnosis may be carried out by “competent” workers in the electrotechnical industry, live repair work must not be carried out. The individual circuit, system or piece of equipment must first be securely isolated before any work is carried out in order to comply with the Electricity at Work Regulations.

Secure electrical isolation and lock off

While the fault diagnosis process **may** be carried out on energized systems and equipment by a "competent" worker, live repair work must **not** be carried out.

The installation, system, circuit or piece of equipment must be securely isolated before repair work commences:

- The IEE Regulations tell us that every circuit must be provided with a means of isolation.
- The Electricity at Work Regulations tell us that before work commences on electrical equipment it must be disconnected from the source of supply and that the disconnection must be secure.
- A small padlock or the removal of fuses or MCBs will ensure the security of the disconnection.
- Where a test instrument or voltage indicator is used to prove the supply dead, the same device must be tested to prove it is still working.
- The test leads and probes of the test instrument must comply with the Health and Safety Executive (HSE) Guidance Note 38 giving adequate protection to the user.
- To deter anyone from reconnecting the supply, a notice must be fixed on the isolator saying "Danger – Electrician at Work".

A suitable electrical isolation procedure is shown over the page, which you should practice in the workshop under the guidance of your lecturer.

"Proving" equipment

The voltage indicator or instrument used to verify the isolation (to "verify" means to check the truth or correctness of the isolation) must itself be "proved" to be working correctly after the verification test has taken place. This is done by testing the voltage indicator on a known supply or proving unit such as that shown in Fig. 7.1.

On load, off load switching devices

Not all switches are designed to switch circuits on and off. When a current is flowing in a circuit, the operation of the switch will result in a discharge of energy across the switch terminals. Functional switches, for normal operations, are designed and manufactured for this purpose. An isolator switch is normally designed for off load switching. The circuit is first made dead by the functional switch and, therefore, no load current is flowing when the isolator is operated.

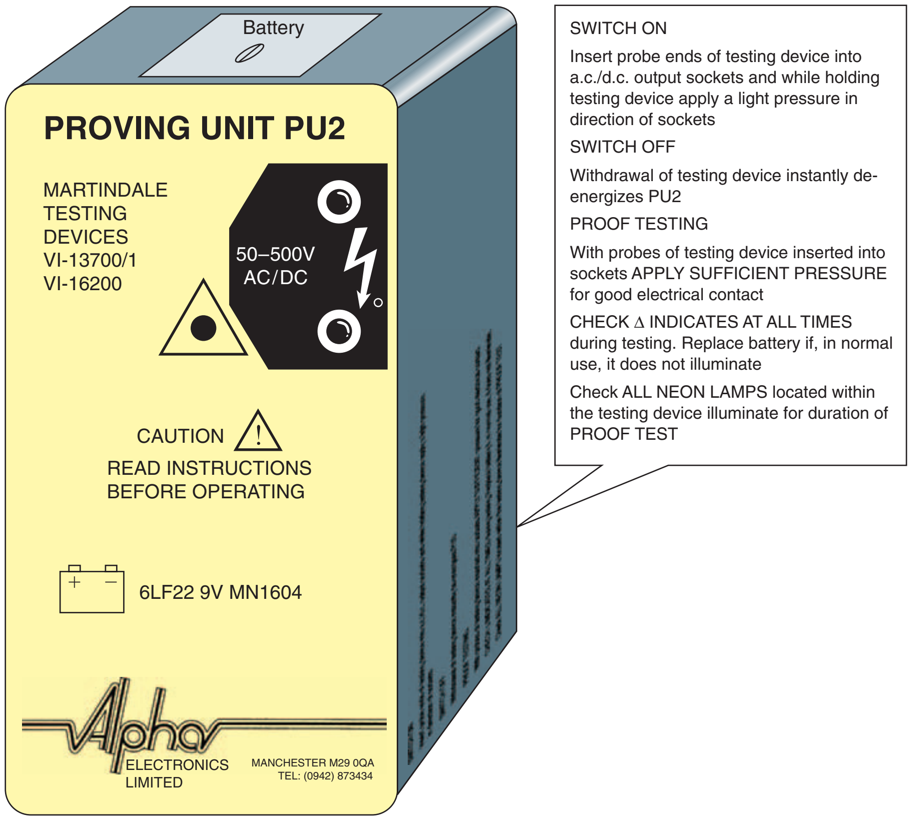


FIGURE 7.1
Voltage proving unit.

Restoration of the supply

When the fault has been rectified, which might involve parts being replaced or sections being re-wired, the supply should be restored and functional checks made to ensure that the system, circuit or piece of equipment performs, as it should. Some additional testing may be necessary to confirm safety and compliance with BS 7671 at the discretion of the "competent" person.

Secure isolation procedures

Start at the top of the flowchart shown in Fig. 7.2 and work your way down. When you get to the heavy outlined amber boxes, pause and ask yourself if everything is satisfactory up to this point. If the answer is **yes**, move on. If **no**, go back as indicated by the arrows.

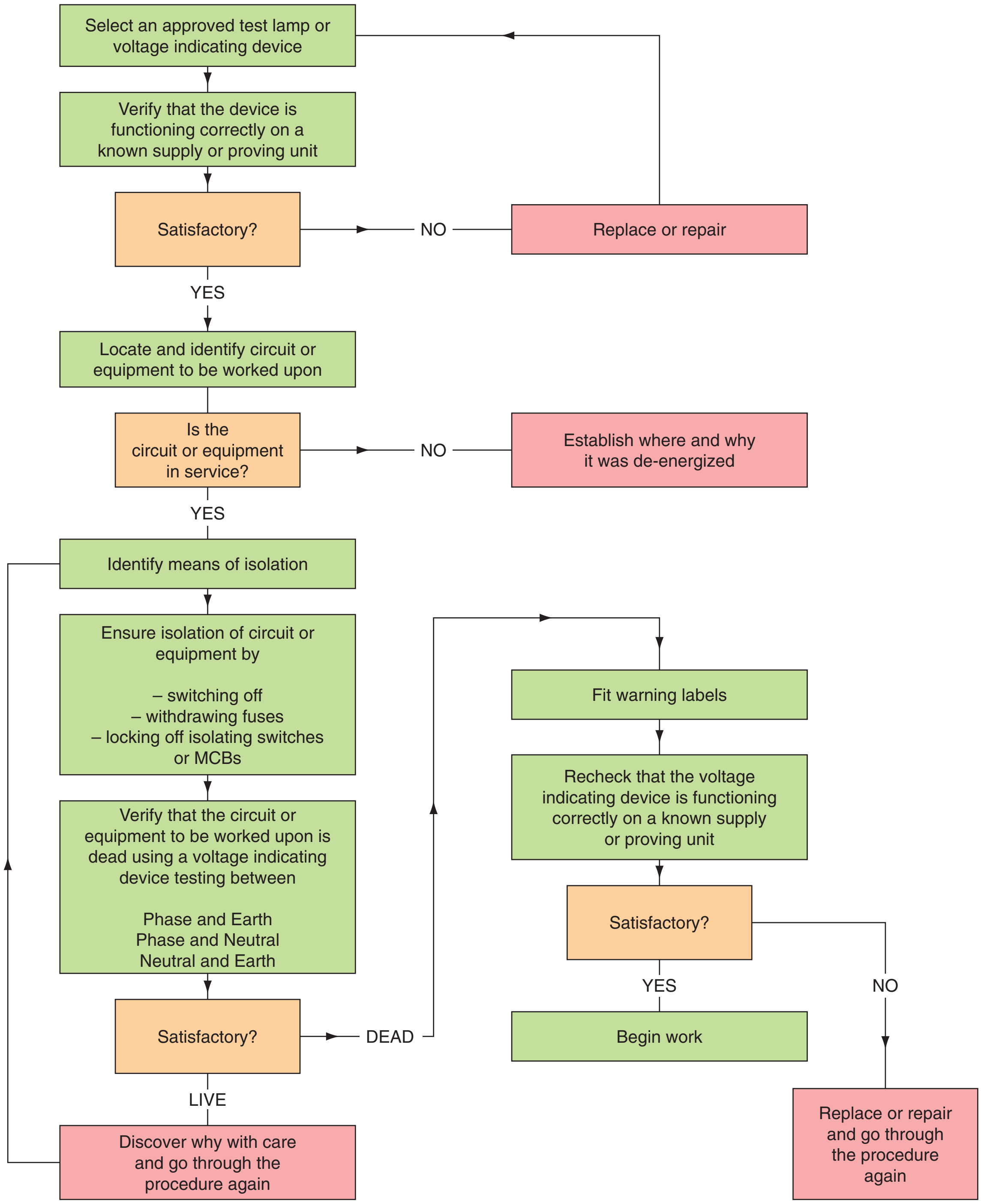


FIGURE 7.2
Flowchart for a secure isolation procedure.

Further information can be found on pages 314 to 318 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Safe working procedures

Read Handouts 1 and 2 and then answer the following questions.

Briefly state what we mean by on load, offload switching and give **one** example.

On load switching . . . .

. . . .

. . . .

. . . .

Off load switching . . . .

. . . .

. . . .

. . . .

What do we mean by a “competent person”?

A “competent person” is one . . . .

. . . .

. . . .

. . . .

Why do we use proving equipment?

Proving equipment is used . . . .

. . . .

. . . .

. . . .

What do we mean by a "secure electrical isolation"?

A secure electrical isolation is. . . . .

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What does the HSE Guidance Note 38 tell us about the test leads and probes of electrical instruments?

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Further information can be found on pages 314 to 318 and 386 to 393 of *Advanced Electrical Installation Work* 5th Edition, 9780750687522.

Electrical faults – symptoms

What do we mean when we say we have an electrical fault on an electrical circuit or system or a piece of electrical equipment? We are saying that things are not working as they should be working because:

- **There has been a complete loss of supply at the origin.**

This might suggest a problem with the supply authority's cable. In general, electrical supplies in the United Kingdom and Europe are very reliable and indeed, our western way of life assumes a reliable source of electrical energy. However, if an underground electrical cable was severed by workers digging a hole, this would cause a complete loss of supply at the origin.

Additionally, a fault on the electrical installation wiring may also result in the supply authority's protective devices operating. However, this would only happen as a consequence of poor electrical design, misuse of the equipment or overloading of the supply. Properly installed graded protection for effective fault discrimination will prevent this occurring.

- **There has been a localized loss of supply.**

A localized loss of supply is more desirable than a complete loss of supply. If a fault occurs on any one final circuit, then only that circuit's protective device should operate in a well-designed installation, leaving only that one circuit dead.

IEE Regulation 314.1 states that every installation shall be divided into circuits as necessary to avoid danger and minimize inconvenience, inspection, testing and maintenance.

- **The overload or fault current devices are operating.**

The fuses are blowing or the MCBs are tripping because of an overload or fault. This is desirable; this is what the protective devices are designed to do. They react to an overload or fault before a dangerous situation arises. The task of the electrician is to diagnose why it is occurring. Overcurrent leads to an increase in temperature of the circuit conductors and equipment. High fault currents may damage equipment and earth faults may also endanger humans and animals.

The overload may have been caused by adding additional circuits or load to an existing installation without due consideration for the design of the installation. Fault currents may be caused by damage to the electrical installation or as a result of a fault of negligible impedance flowing between conductors or to earth.

- **Transient voltages are occurring.**

A transient voltage is an increase in voltage lasting for a very short period of time (microseconds) on the a.c. mains supply. Transient means quickly passing away, of short duration. These distortions to the normal clean a.c. supply cause problems for information technology systems, leading to a loss of data. A transient voltage spike and "noise" are shown in Fig. 7.3.

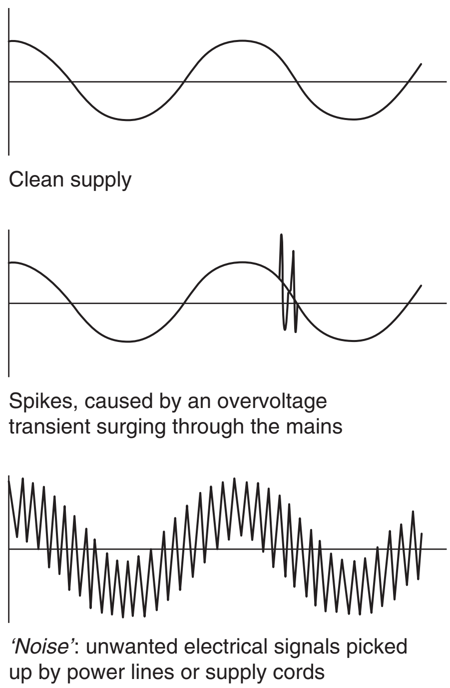

FIGURE 7.3
Distortions in the a.c. mains supply.

Transient voltages may be caused by supply company switching, heavy current switching within the electrical installation itself, lightning strikes or earth fault voltages.

The installation designer can prevent some transient voltages occurring by installing soft start equipment on heavy current using machines and equipment. Alternatively electronic equipment which protects against these voltage variations and disturbances such as stabilized power supplies and uninterruptible power supplies (UPS) are available if this is a recurring problem or the data is particularly sensitive.

- **Insulation failure is occurring.**

Insulation is used to separate conductors and to protect those who will use the installation from electric shock by protecting against direct contact with live parts and called "Basic Protection" (IEE Regulations Section 416).

If you suspect that the insulation has become damaged, then you must carry out the insulation resistance test recommended by IEE Regulation 612.3.

The causes of insulation resistance failure are usually linked to an increase in temperature. This may be caused by localized heating, loose connections at switch contacts, localized heating in luminaires, poor installation methods, poor maintenance, poor design of the installation and non-compliance with Part 5 of the IEE Regulations Selection and Erection of Equipment.

- **Component failure is occurring.**

Some components fail because they are not capable of doing the job asked of them, the rating is too low or they are operating in conditions for which they were not designed. Some components and equipment fail simply because they are used day in and day out and eventually they fail because they have come to the end of their designed lifetime.

Lamps are designed to last a pre-determined number of hours. GLS lamps have an intended lifespan of 1000 hours, tungsten halogen lamps 2000 hours and fluorescent tubes and most discharge lamps between 5000 and 7500 hours. If the lamps are on 24 hours each day, 7 days each week you can work out how many days and weeks they are designed to last.

Functional switches are designed to operate for "n" thousand operations in order to meet the manufacturing standard but switches sometimes fail prematurely because they are operating inductive loads such as discharge lighting. The Appendix to the On Site Guide tells us that where more exact information is not available, the rating of discharge circuits must be multiplied by a factor of 1.8. We usually also choose the rating of switches operating discharge circuits to be twice the total steady current of the discharge circuit to take account of the excessive wear at the functional switch contacts.

The d.c. motors wear out carbon brushes which eventually need replacing but a.c. motors with lifetime bearings such as those used on central heating systems require no attention.

Whether the component failed because it was not suitable for the job asked of it or because it had come to the end of its designated life, it is for the electrician trying to diagnose the cause of the fault to make that decision. Good initial design using good quality components, good installation practice and good maintenance all help to extend the life of electrical components, equipment and systems.

Electrical faults – where do they occur?

Electrical faults may occur in electrotechnical systems at the following places:

(a) the wiring system

(b) at cable terminations

(c) within accessories, switchgear, contactors and controls

(d) within instrumentation and metering equipment

(e) at protective devices

(f) at luminaires

(g) in flexible cables and cords

(h) in electrical components.

Let us look at each of these potential fault situations.

Electrical faults in the wiring system

The electrical designer will choose a wiring system which meets the needs of the client and any relevant regulations. Part 5 of the IEE Regulations deals with the selection and erection of equipment and the designer must choose a wiring system which complies. For example:

> *the wiring system must be suitable for the installed conditions such as temperature, presence of water, vibration, corrosion and solar radiation*

The electrician must install the wiring system competently and in compliance with the IEE Regulations. For example:

> *buried cables must have mechanical protection … and underground cables must be buried at sufficient depth to prevent future damage. Cables installed in timber joists must be at least 50 mm from the top and bottom of the joist … and the installed wiring system must not reduce the safety of the building structure.*

A suitable wiring system, correctly installed will cause few problems in the future. It is where the human hand has been involved at each end of the wiring system there future problems most often occur.

Electrical faults at cable terminations

Cables are terminated in switches, socket outlets, consumer units and joint boxes.

Wherever they are terminated, every connection and joint must be accessible for inspection and testing (IEE Regulations 513.1 and 526.3). The only exception is compound encapsulated joints underground, a connection between a cold tail and heating element under floor and a joint made by welding, soldering, brazing or compression tool.

Where a cable enters an accessory the integrity of the conductor's insulation and sheath must be maintained. That is, the cable sheath must enter the accessory and be securely held.

All electrical connections must be mechanically and electrically sound and securely anchored to all connections. The quality of the connection depends on the skill and good practice demonstrated by the installing electrician. The accessory or device used for making the connections must be of the correct size for the cable conductors.

Cable connection points are the first point of contact when investigating faults because:

- they are seen as the weak link
- they are accessible
- they provide a point for further testing and investigation.

The most common cable termination faults are:

- poor or loose connections
- a lack of cable support
- strain being placed on the conductors.

Electrical faults within accessories, switchgear, contactors and controls

Faults can occur on any piece of electrical equipment used in the home, office or industry. The most common type of fault on electrical accessories, such as switches is due to regular and repeated making and breaking of the load and the consequent arcing that occurs with every switch operation especially when discharge lighting is being switched.

Sockets in kitchens are probably most frequently used and carry the heaviest loads.

When faults occur on these accessories the solution is usually a new replacement (see also Handout 3, component failure).

Contactors are often used in industry to switch heavy loads, sometimes remotely, using a magnetic coil to close the contacts. Repeated making and breaking of the load causes arcing and wear on the switch contacts which may lead to faults occurring.

The operating coils may also burn out and require replacing.

The smaller contactors used in electronic control equipment are usually encapsulated in a plastic container and when these are faulty the only solution is a replacement.

Most electronic and solid-state devices are not repairable and when found to be faulty must be replaced with an exact replacement.

Remember also that most electronic equipment can be damaged by the tests recommended by the IEE Regulations and should be disconnected before testing commences.

Electrical faults within instrumentation and metering equipment

Instrumentation systems using sensors, transducers and PLCs monitor and control industrial processes. These systems are often low voltage and use electronic and solid-state devices encapsulated in "black boxes".

Industrial instrumentation systems often monitor and control at a safe distance, toxic and unhealthy processes and "instrumentation" is one of the specialist branches of the electrotechnical industry.

The metering equipment used in industrial and commercial installations uses standard instruments with CTs and VTs to record large currents and voltages. When faults occur on this equipment, the solution is often the replacement of the CTs and VTs. However, because large currents and voltages are often present, the repair can only be carried out after following the recommended safe isolation procedure and obtaining any necessary work permits.

Electrical faults at protective devices

Protective devices are designed to remove an overload or fault before a dangerous situation arises.

If the protective device has operated it is for the electrician to diagnose why it has happened. The protective device should only be reset after the fault has been investigated and corrected. The electrician should also check that the protective device is appropriate for the circuit in terms of type and rating.

Electrical faults in luminaires

A luminaire is a light fitting designed to support a lamp and to distribute or filter the light from the lamp. It contains a lamp, and in the case of discharge lamps, a pf correction capacitor, a ballast choke and a starter lamp (canister) or electronic quick start unit.

Any of these components may require replacing but always start by replacing the lamp.

Electrical faults in flexible cables and cords

Flexible cables and cords are used to connect electrical equipment to the fixed wiring system from:

- fused 13 A plug tops to portable appliances
- flexible cord outlet spur units to towel rails and fans
- pendant ceiling roses to lampholders.

The problems associated with flexible cables and cords are:

- not terminating all the flexible strands into the connection
- using a flexible cord which is too small for the load
- using a flexible cord which is not designed for the installed temperature conditions
- putting strain on the connections by not securing the cord grips.

Electrical faults in electrical components

Some electrical components fail because they are not suitable for the task asked of them, for example the rating is too low or they are operating in conditions for which they were not designed. Others fail because they have come to the end of their designed lifetime. For most faults which are traced to a failed component, the solution is usually a replacement.

This will probably require the disconnection of the old component, obtaining a new one and reconnecting. It is always good practice to make a drawing of the connections or mark the conductors with the connection reference numbers or letters before removing the damaged component.

All connections must be made carefully into the conductor terminations:

- Pillar terminals have a hole through the side into which the conductors are inserted and which are then clamped by screwing a screw down on to them. If the conductor is small in relation to the hole, it should be doubled back.

- Screw head terminals should be unscrewed and the conductor formed into an eye using a screwdriver or a pair of long-nosed pliers. The eye should be larger than the shank but smaller than the outside diameter of the screw head. The eye should be placed under the screw head, so that as the screw is tightened, it closes the joint in the eye (usually clockwise).

- Claw washers are made from two washers, one flat and one shaped like a crown. The conductor is placed on the crown, the flat washer is then placed over the conductor within the crown and the points of the crown are then folded over the flat washer.

- Strip connectors or chocolate blocks. The conductors to be terminated are clamped by grub screws in brass connectors mounted in a coloured or clear plastic block.

All electrical connections are potential sources of faults. All electrical connections must be mechanically and electrically sound and all conductors must be secured.

Electrical faults

Read Handouts 3 and 4 and then give **three** short sharp possible reasons why faults might occur in each of the situations given below.

A PVC/SWA cable laid underground supplying a remote building.

- ....
- ....
- ....

PVC insulated and sheathed cables buried in the plaster of a domestic installation and feeding a ring main of socket outlets.

- ....
- ....
- ....

Where cables are terminated in the switches and socket outlets of a domestic installation.

- ....
- ....
- ....

Where cables are terminated in the switches of a domestic kitchen lighting installation incorporating hidden fluorescents under the wall cupboards.

- ....
- ....
- ....

Where the cables are terminated in the loop-in lighting points of a domestic installation.

- ....
- ....
- ....

The MCB protective device of a domestic installation feeding socket outlets has tripped. The householder has tried to reset the MCB but it will not latch and all the sockets are therefore dead.

- ....
- ....
- ....

A school classroom is illuminated by 15 modular luminaires in a suspended ceiling. Five of the luminaires are not working.

- ....
- ....
- ....

A wind-up drum extension lead is used in a domestic situation for very general work, connecting tools and garden equipment. Sometimes the tools work when connected and sometimes they do not.

- ....
- ....
- ....

The three-phase circular saw in a kitchen manufacturer's workshop is switched on by the operator pressing a start/stop button. When it came to be used as normal at the beginning of the working day it would not start, it seemed to be dead. It was working at the end of work the day before.

- ……………………………………………………………………………………

  ……………………………………………………………………………………
- ……………………………………………………………………………………

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- ……………………………………………………………………………………

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A new Local Authority Data Base Centre is being established in refurbished offices on an existing retail and industrial park on the outskirts of a city. Your company did all the electrical installation work but a specialist company did the data cabling for the IT systems. During the commissioning of the IT systems, the systems behaviour became erratic and some data has been lost. The IT Manager is frustrated and talking about spikes and transients. What do you think he is talking about and what can be done?

- Spikes and transients are ……………………………………………………………

  ……………………………………………………………………………………

  ……………………………………………………………………………………

  ……………………………………………………………………………………

  ……………………………………………………………………………………
- Possible solutions ……………………………………………………………………

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Factors influencing the repair or replacement of equipment

You have been called in by a client to diagnose and repair a fault on some equipment. Having diagnosed the cause of the fault you must then decide how you will proceed to a satisfactory repair or replacement so that the equipment can be back in service as soon as possible.

These are some of the factors which might influence the decision.

Costs

- The "downtime" of some pieces of equipment is very expensive to a company because it is an essential part of a bigger process.
- Can this fault or this piece of equipment be repaired quickly?
- Can a temporary repair be made to get this equipment or process working temporarily or for a period of time until it would be more convenient to carry out the full repair?
- Will it be expensive to purchase replacement parts, components or equipment to repair this equipment. For example, it might be an American or German machine which requires parts which can only be obtained from the country of manufacture.
- Is your company prepared to put men on to this job immediately to solve the problem when you have other clients who also require your services?
- Does your company have a prior agreement with this client to provide emergency or service work at some pre-determined rates?
- Is the client such a good client that you cannot afford to lose his work and are, therefore, committed to helping him solve this problem?

A representative from the electrical company you work for must agree a way forward with client's representative before remedial work is undertaken because these decisions will have cost implications.

Availability of replacement parts

- Do you require a few specialist parts to repair this equipment or process or
- Do you require a completely new machine because the old one is damaged beyond repair?
- If it is damaged beyond repair, is it because it is new and a critical fault has caused excessive damage or
- Is it old equipment or systems which have come to the end of their lifespan?
- Have you and your company been "nursing" this equipment along for some time, just keeping it going?
- If it is new equipment or a new system then new parts are probably available, but how long will it take to get them?
- If the equipment is obsolete, you may have to find a replacement which closely matches the faulty equipment?
- Is the original manufacturer still in business? Do manufacturers of this type of equipment still trade in the United Kingdom or Europe?
- If you can find an exact replacement part or a replacement which closely matches the faulty equipment and the manufacturers have the part in stock, then this is probably the way forward. Small components can be put in "jiffy" bags and posted; larger parts take longer to arrive. Alternatively, you may be able to collect the item concerned.
- The actions you take at this stage will depend on how important it is to get the fault repaired quickly.

Downtime under fault conditions

- The downtime of some equipment is very costly because it may form an essential part of a bigger process.
- The downtime might lead to a loss of production and workers standing idle, unable to work.
- If the fault has caused a power failure, IT systems and data may have been lost.
- If a power failure is going to be prolonged, it may be possible to provide temporary supplies from another part of the building or from standby generators to keep the process going while repairs are undertaken.

Legal responsibilities – warranties

- Once your electrical company has agreed to undertake the rectification of a fault, they are entering into a contract with the client to carry out that work. This step must not be taken without due consideration to the risks involved and must be taken by a representative of the electrical company with the authority to do so. The fault rectification work, like all work carried out by an electrical contractor, will carry a guarantee of "fitness for purpose". That is, we are saying it will meet the requirements of the Regulations and it will not break down again for a reasonable period of time once this work has been carried out. The contract may be verbal or written down but either will be legally binding.
- In the initial stages the client's main concern will probably be to rectify the fault and get the process working again as quickly as possible. During this initial "panic" stage, clients often say "just get the fault repaired and don't worry about the cost". It is only afterwards when everything is calm and working well, or when the client receives the account for the repair that he might wonder if the repair could have been carried out more cheaply.
- The electrical contractor is in business and if he wants to remain in a profitable business, he must take time in the initial stages to agree the costs involved in the repair work. It is normal practice to carry out repair work on a "daily rate" where the client pays for the labour and material used to repair the fault to the satisfaction of both parties. If your company does not have a pre-arranged agreement with this client for repair work of this kind, it is always worthwhile putting the basic costs down on paper and obtaining a signature of authorization to proceed.
- If you replace faulty equipment with new equipment, then that equipment will carry a warranty of probably 1 year. If the equipment becomes faulty within the warranty period, then the electrical contractor will replace it without cost to the client/customer.
- If you have decided to reuse or repair equipment rather than replace it with new, then this equipment will probably not carry any warranty. The extent of what is included in the warranty must be agreed with the client or their representative and written into the contract, either before work commences or at the conclusion of the work to avoid any misunderstanding at a later date.

Factors influencing the replacement or repair of equipment

The City & Guilds Syllabus asks us to consider **four** factors which might influence the decision to repair or replace broken or damaged equipment. I would, therefore, like you to read Handout 5 and, using bullet points, answer the following questions:

State **four** important costs which a client or customer faces when equipment in their factory or offices has broken down

- ....

  ....
- ....

  ....
- ....

  ....
- ....

  ....

State **four** important considerations with regard to the availability of replacement parts

- ....

  ....
- ....

  ....
- ....

  ....
- ....

  ....

State **four** important considerations relating to the "downtime" under fault conditions

- ....

  ....
- ....

  ....
- ....

  ....
- ....

  ....

State **four** important legal responsibilities of an electrical contractor undertaking the task of fault repair

- ....

  ....
- ....

  ....
- ....

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- ....

  ....

Situations where special precautions must be applied

The City & Guilds Syllabus asks us to look at **six** situations where special precautions must be considered for our own safety. For each of the **six** situations stated below answer the questions in the spaces provided.

1. Fibre Optic Cables

(a) What are they?. . . . .

. . . .

(b) Where are they used? . . . .

. . . .

(c) How are they joined? . . . .

. . . .

(d) What are the dangers associated with fibre optic cables? . . . .

. . . .

2. Anti-static Precautions

(a) What is static electricity? . . . .

. . . .

(b) Give **one** example where a static charge might build up . . . .

. . . .

(c) State the dangers associated with a build up of static charge . . . .

. . . .

(d) State ways to eliminate a build up of static charge. . . . .

. . . .

3. Damage to Electronic Devices by Overvoltage

(a) What do we mean by overvoltage in this case? ....

....

(b) In what circumstances might a voltage in excess of the normal voltage be applied to electronic equipment? ....

....

(c) What are the risks associated with overvoltage to electronic devices? ....

....

(d) How would you avoid damaging electronic equipment when carrying out tests recommended by the IEE Regulations (BS 7671)? ....

....

4. Avoiding Shut Down of IT Equipment

(a) What is the risk associated with the sudden shutdown (loss of supply) to IT equipment? ....

....

(b) What do we mean by a clean supply? ....

....

(c) What mains carried distortions can provoke errors in a computer network? ....

....

(d) How do we avoid the sudden shutdown of IT equipment? ....

....

5. Risk of High Frequency or Large Capacitive Circuits

(a) Give an example of a piece of equipment or process which uses high frequency power . . . .

. . . .

(b) What is the risk to people associated with high frequency power? . . . .

. . . .

(c) Where would you find a capacitor? . . . .

. . . .

(d) What do capacitors do?. . . . .

. . . .

(e) What is the risk associated with large capacitive circuits? . . . .

. . . .

6. Presence of Storage Batteries

(a) Where might you find large capacity storage batteries being used? . . . .

. . . .

(b) What are the dangers associated with large capacity storage batteries? . . . .

. . . .

(c) What would make a battery charging room safe to work in? . . . .

. . . .

(d) What precautions should electricians take when working with large capacity storage batteries? . . . .

. . . .

(e) What would you use to top up a car battery?. . . . .

. . . .

Further information can be found on pages 259 to 267 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Disposal of waste material

Having successfully diagnosed the electrical fault and carried out the necessary rectification we come to the final task:

- leaving the site in a clean and safe condition
- disposing of all waste material.

In Unit 4 of this tutor support material, we looked at the regulations which relate to waste materials. That is:

- The Controlled Waste Regulations 1998.
- These tell us that we have a "duty of care" to handle, recover and dispose of waste "responsibly".
- The Environmental Protection (Duty of Care) Regulations 1991.
- These tell us that any business has a duty of care to handle any waste that it produces according to the law.

Waste material which is potentially hazardous is covered by:

- Special Waste Regulations 1996.
- This includes materials such as asbestos and from July 2005, it also includes discharge lamps, batteries, disused electronic equipment and electronic equipment cartridges and any other equipment with an orange hazard label placed upon it by the manufacturer.

Electrotechnical companies produce relatively small amounts of waste and even smaller amounts of hazardous waste, so what do you do with the waste that the working environment produces. Well, most of the general site waste goes into the skip for disposal in the local council's landfill area.

Special waste is a problem which most electrotechnical companies solve by buying in the expertise of a specialist company and passing the cost on to the client/customer. Specialist companies have systems and procedures, which comply with the Regulations. Essentially, when they remove your "special waste", they will give you a "Waste Transfer Note" which identifies what was taken and its final place of disposal. These notes must be filed carefully in the job file as evidence that you have disposed of your waste responsibly and within the law.

Discharge lamps are now classified as special waste and cannot, therefore, be placed in the general site skip. These lamps contain mercury and sodium and were given special waste classification under the 2003 UK Waste Regulations. This means that they must be either:

- crushed in a lamp crusher and disposed of as special waste or
- be completely recycled.

The electrical wholesaler C.E.F. (City Electrical Factors) have joined forces with "Lampcare U.K. Recycling" to offer a new service to customers, the complete recycling of discharge lamps including the glass, end caps and the mercury and sodium contained within these lamps.

It works like this, C.E.F. will arrange for a suitable expired lamp container to be delivered either to your site or the company stores. Expired lamps can then be placed in the container and when full, returned to C.E.F. They will issue a Duty of Care Note and full recycling documents and charge approximately 50p for each 1800 mm tube or 50p for three 600 mm tubes. The lamps are then completely recycled at Lampcare's specialist recycling plants.

Disposal of waste material – safe and clean site conditions

1. Having completed the fault diagnosis and repaired the equipment, what should you do with the left over conduit, cables, packaging, tools and equipment brought on to the site to repair the fault?

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2. (a) What do we mean by the "general waste container"?

. . . .

. . . .

(b) What normally goes into the general waste container?

. . . .

. . . .

(c) What do we mean by hazardous waste?

. . . .

. . . .

(d) Give an example of hazardous waste material

. . . .

. . . .

. . . .

(e) What is a "Waste Transfer Note"?

. . . .

. . . .

3. (a) What do we mean by a "duty of care"?

. . . .

. . . .

(b) Who holds a "duty of care" for the team that you work with?

. . . .

. . . .

Further information can be found on pages 373 to 375 of *Advanced Electrical Installation Work* 5th Edition, ISBN 9780750687522.

Note: More than one answer may be correct.

1. **Fault diagnosis means to:**
   a. understand the system or piece of equipment ☐
   b. have a knowledge of the system or piece of equipment ☐
   c. determine the nature of the fault ☐
   d. repair the fault. ☐

2. **Fault rectification means to:**
   a. understand the system or piece of equipment ☐
   b. have a knowledge of the system or piece of equipment ☐
   c. determine the nature of the fault ☐
   d. repair the fault. ☐

3. **The ideal way to diagnose a fault is:**
   a. follow a reasoned and logical approach ☐
   b. follow a safe isolation procedure ☐
   c. employ a “competent” person ☐
   d. work quickly and look confident. ☐

4. **Having diagnosed the fault, repair work should be carried out:**
   a. following a reasoned and logical approach ☐
   b. following a safe isolation procedure ☐
   c. by a “competent” person ☐
   d. by working quickly and looking confident. ☐

5. **On load switching devices:**
   a. only switch motor circuits ☐
   b. only switch discharge lighting circuits ☐
   c. break the circuit with a discharge of energy across the terminals ☐
   d. break the circuit without a discharge of energy across the terminals. ☐

6. **Offload switching devices:**
   a. only switch motor circuits ☐
   b. only switch discharge lighting circuits ☐
   c. break the circuit with a discharge of energy across the terminals ☐
   d. break the circuit without a discharge of energy across the terminals. ☐

7. **Isolator switches:**
   a. only switch motor circuits ☐
   b. only switch discharge lighting circuits ☐
   c. break the circuit with a discharge of energy across the terminals ☐
   d. break the circuit without a discharge of energy across the terminals. ☐

8. **Functional switches**
   a. only switch motor circuits ☐
   b. only switch discharge lighting circuits ☐
   c. break the circuit with a discharge of energy across the terminals ☐
   d. break the circuit without a discharge of energy across the terminals. ☐

9. Following any isolation, the voltage indicator used to verify the isolation must itself be:
a. verified to be working correctly ☐
b. proved to be working correctly ☐
c. calibrated regularly to maintain its accuracy ☐
d. fitted with GS 38 compliant leads. ☐

10. Any test instrument used for electrical testing must be:
a. verified to be working correctly ☐
b. proved to be working correctly ☐
c. calibrated regularly to maintain its accuracy ☐
d. fitted with GS 38 compliant leads. ☐

11. An electrical isolation may be secured by:
a. switching off all functional switches on the circuit ☐
b. switching off the local isolation switch ☐
c. removing the circuit fuse ☐
d. fitting a small padlock to the circuit MCB. ☐

12. Test leads which have robust leads, an in line fuse, barriers to prevent access to live terminals and shrouded connectors are:
a. IEE Regulation BS 7671 compliant ☐
b. BSEN 61557 compliant ☐
c. Electricity at Work Regulations compliant ☐
d. HSE Guidance Note GS 38 compliant. ☐

13. If we say that an electrical fault has caused a complete loss of supply at the origin, we mean that:
a. a piece of equipment or system has failed because of a small part failure ☐
b. the circuit fuses are blowing or the MCBs are tripping ☐
c. all final circuits on the electrical system are down (not working) ☐
d. one or two final circuits on the electrical system are down (not working). ☐

14. If we say that an electrical fault has caused a localized loss of supply, we mean that:
a. a piece of equipment or system has failed because of a small part failure ☐
b. the circuit fuses are blowing or the MCBs are tripping ☐
c. all final circuits on the electrical system are down (not working) ☐
d. one or two final circuits on the electrical system are down (not working). ☐

15. If we say that the fault current or overload devices are operating, we mean that:
a. a piece of equipment or system has failed because of a small part failure ☐
b. the circuit fuses are blowing or the MCBs are tripping ☐
c. all final circuits on the electrical system are down (not working) ☐
d. one or two final circuits on the electrical system are down (not working). ☐

16. If we say that there has been a component failure we mean that:
a. a piece of equipment or system has failed because of a small part failure ☐
b. the circuit fuses are blowing or the MCBs are tripping ☐
c. all final circuits on the electrical system are down (not working) ☐
d. one or two final circuits on the electrical system are down (not working). ☐

17. Electrical components fail because they:
a. distribute or filter the light energy from a lamp ☐
b. are not suitable for the task asked of them ☐
c. support a lamp ☐
d. have come to the end of their lifespan. ☐

18. Luminaires:
a. distribute or filter the light energy from a lamp ☐
b. are not suitable for the task asked of them ☐
c. support a lamp ☐
d. have come to the end of their lifespan. ☐

19. The most probable cause of a fault on a discharge luminaire is:
a. the functional switch is in the "off" position ☐
b. the fitting has become disconnected ☐
c. the ballast choke is faulty ☐
d. the lamp has failed. ☐

20. All electrical connections:
a. are a potential source of electrical faults ☐
b. must be terminated with brass terminal screws ☐
c. must be mechanically and electrically sound ☐
d. must be accessible, including those made by a compression tool. ☐

21. The most common cause of a cable termination fault is:
a. the local isolator has been switched off ☐
b. the canister starter has failed on the fluorescent circuit ☐
c. poor or loose connections ☐
d. strain being placed on the conductor by a lack of cable support. ☐

22. The cost of a fault on an industrial process is often very expensive because:
a. the HSE Inspectors can fine companies for industrial breakdowns ☐
b. breakdowns slow down or stop the main production process ☐
c. breakdowns prevent workers from working ☐
d. the Unions can encourage their members to strike action. ☐

23. Fibre optic cable conductors:
a. are made of optical glass ☐
b. are made of optical quality plastic ☐
c. carry laser light digital signals ☐
d. look very like SWA cables but lighter. ☐

24. Static electricity is:
a. transmitted on the National Grid ☐
b. available from the area electricity suppliers ☐
c. a voltage charge which may be thousands of volts ☐
d. available from a standby diesel generator. ☐

25. A static charge can be eliminated by:
- a. disconnecting the mains supply ☐
- b. switching off the main supply at an isolator ☐
- c. bonding surfaces together ☐
- d. fitting a label – **DO NOT REMOVE – SAFETY ELECTRICAL EARTH**.

26. Overvoltage may be defined as:
- a. a voltage in excess of the rated voltage ☐
- b. a voltage in excess of 230V ☐
- c. a voltage in excess of 400V ☐
- d. a voltage in excess of 1000V. ☐

27. A small transient overvoltage can cause:
- a. MCBs to trip ☐
- b. conductors to overheat ☐
- c. insulation to break down ☐
- d. computer systems to crash. ☐

28. Electricity supply cable "spikes" can cause:
- a. leaks in the water mains ☐
- b. underground supply cables to explode ☐
- c. a loss of the mains supply ☐
- d. computer systems to crash. ☐

29. A sudden failure of the mains supply can lead to:
- a. damage to the circuit conductors insulation ☐
- b. the circuit protective devices being operated ☐
- c. the emergency lighting systems being operated ☐
- d. a loss of computer data/information. ☐

30. A "clean" a.c. mains supply:
- a. does not have dirty insulation ☐
- b. has a very low resistance ☐
- c. does not have a power factor exceeding 0.85 ☐
- d. is a pure sine wave without distortion. ☐

31. Power cable supply distortions which may provoke errors in computer systems are called:
- a. slugs ☐
- b. bugs ☐
- c. spikes ☐
- d. tikes. ☐

32. UPS are used to:
- a. maintain an emergency power supply in hospital operating theatres ☐
- b. avoid a loss of important data on computer systems ☐
- c. maintain emergency lighting in the event of mains failure ☐
- d. maintain security lighting in the event of a mains failure. ☐

33. Capacitors:

a. store an electric charge ☐
b. store a d.c. voltage similar to a battery ☐
c. store an a.c. voltage similar to the a.c. mains supply ☐
d. store dilute sulphuric acid similar to a battery. ☐

34. Large-value capacitors used for pf correction:

a. are connected in parallel with the supply ☐
b. often have a high-value discharge resistor connected across their terminals ☐
c. may cause an electric shock if the terminals are touched ☐
d. require RCD protection at the mains supply position. ☐

35. The industrial heating process known as "induction heating" must be treated with caution because it uses:

a. a 400V 50Hz supply ☐
b. laser light in high frequency pulses ☐
c. a high frequency a.c. supply ☐
d. a large capacity d.c. supply. ☐

36. Fork lift truck battery charging rooms should:

a. be close to the battery store ☐
b. be close to the fork lift truck storage area ☐
c. be well ventilated ☐
d. have all surfaces bonded together. ☐

37. During the battery charging process:

a. dilute sulphuric acid is released ☐
b. hydrogen gas is released ☐
c. distilled water droplets are released ☐
d. a large voltage is developed across the battery terminals. ☐

38. When the plates of a car battery are showing, the battery must be "topped up" using:

a. dilute sulphuric acid ☐
b. distilled water ☐
c. hydrogen gas ☐
d. WD 40. ☐

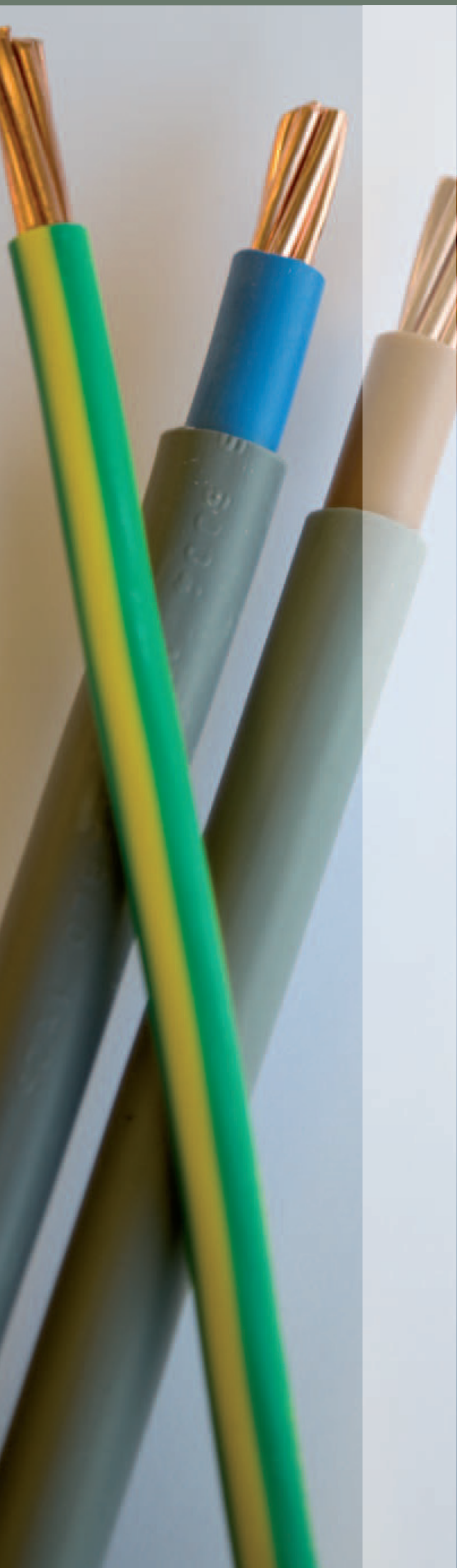
39. "Normal Waste" would be materials such as:

a. asbestos ☐
b. discharge lamps ☐
c. wood and metal ☐
d. paper and cardboard packaging. ☐

40. "Special Waste" would be materials such as:

a. asbestos ☐
b. discharge lamps ☐
c. wood and metal ☐
d. paper and cardboard packaging. ☐

Answers to Worksheets 1 to 13



Worksheet 1

Answers at lecturer's discretion – see Handouts 1 and 2.

Worksheet 2

Answers at lecturer's discretion – see Handouts 3 and 4.

Worksheet 3

Answers at lecturer's discretion – see Handout 5.

Worksheet 4

Answers at lecturer's discretion

1. a. optical quality plastic conductors
   b. IT and data transmission systems
   c. cables are cleanly cut and butted together
   d. avoid direct eye contact with laser light transmitted down conductors

2. a. a voltage charge which may build up to many thousand volts between two surfaces when they rub together
   b. thunderstorm – nylon lab coats crackle – synthetic carpets and man-made footwear result in small electric shocks – shock from car door handle
   c. electric shock – spark may cause explosion
   d. bonding all surfaces – reduce flow rates in pipes – anti-static rubber containing graphite – use natural fibres, cotton and wool in carpets and clothing – increased humidity

3. a. voltage in excess of the rated voltage
   b. mains born transient surges – insulation resistance test
   c. loss of data – destruction of devices
   d. first disconnect/isolate electronic devices

4. a. loss of data/information
   b. a supply without distortion, a pure sine wave
   c. spikes and noise
   d. clean supplies and UPS

5. a. microwave ovens – induction heating processes
   b. deep burns
   c. discharge lighting – motor circuits
   d. pf correction
   e. electric shock

6. a. fork lift truck operations – emergency lighting – telecommunication exchanges

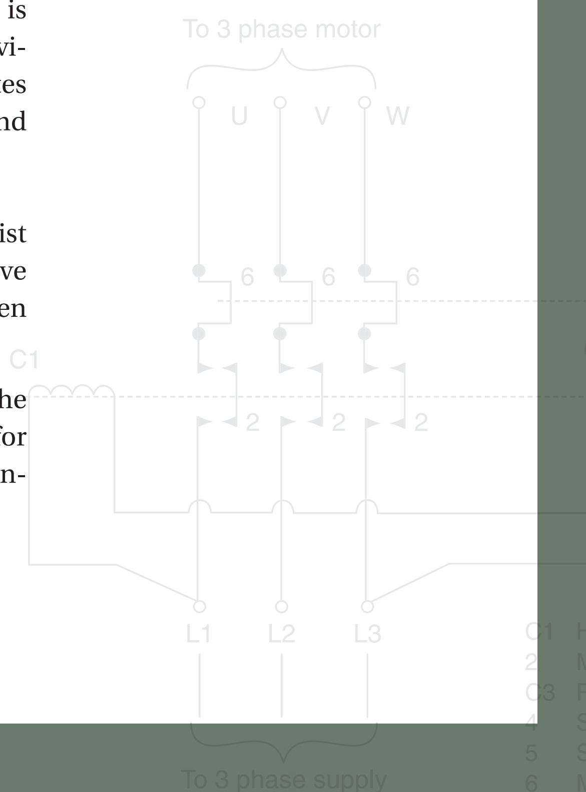
b. hydrogen gas liberated during charging creates explosion risk – sparks or very large currents flowing if terminals are shorted – spills of dilute sulphuric acid – personal contact with dilute sulphuric acid
c. fume extraction system
d. reduce contact with dilute sulphuric acid – wash hands – acid rots clothes – wipe up spills – do not short out terminals deliberately by “flicking” or accidentally by tools falling out of top pocket as you bend over – top up cells with distilled water so that plates are covered – always add concentrated acid to water when making dilute sulphuric acid, **never** add water to concentrated acid because it will “spit” due to exothermic reaction – wear eye protection
e. distilled water.

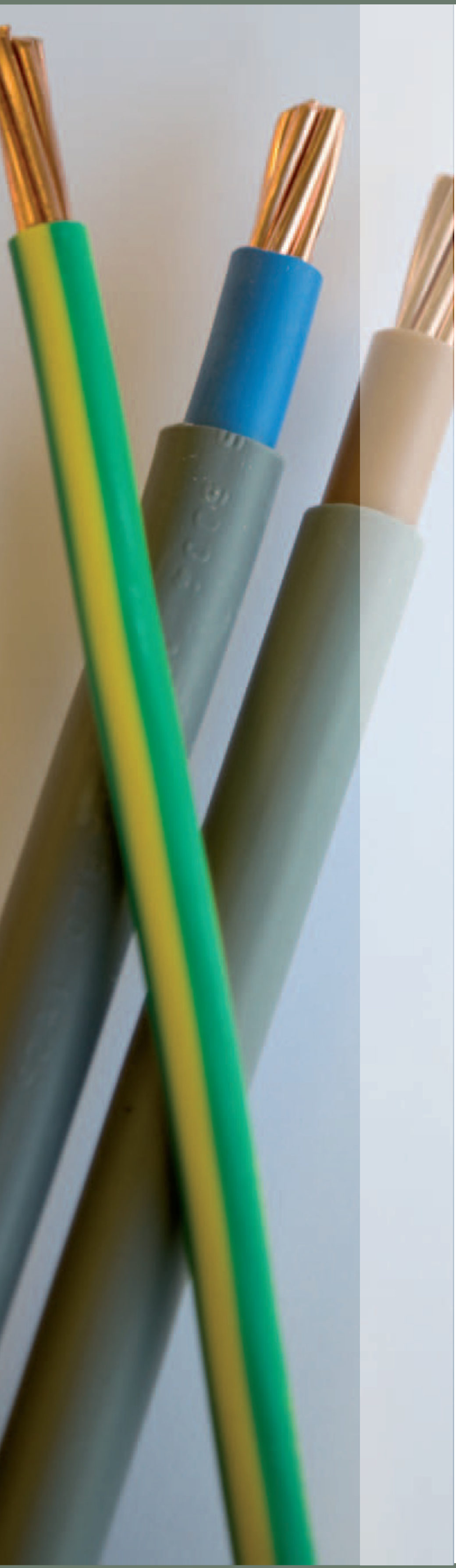
Worksheet 5

1. Remove everything from the site, leaving it clean, tidy and safe. Hopefully the tools and equipment will go back in the company vehicle, the conduit and cable will go back to the company stores and the scrap conduit and packaging will go into a waste skip.

2. a. The normal waste skip whose contents will be tipped on to the local council’s landfill site.
   b. Normal wastes such as packaging, cable drums, scrap conduit and trunking.
   c. The Special Waste Regulations cover Hazardous Waste, that is waste which is potentially dangerous to people or the environment. Hazardous waste is placed in special landfill sites which are and will be monitored by the local Council and Environmental Officers for the foreseeable future.
   d. Asbestos, discharge lamps, batteries, oil and solvents.
   e. A receipt for the hazardous waste handed over to a specialist company, who has a licence to operate. It proves that you have complied with your duty of care and identifies what was taken and when and by whom. File this in a safe place.

3. a. In the context of the Health and Safety at Work Act and the Electricity at Work Regulations, everyone has a duty of care for the health and safety and environment at work. It is a responsibility that we all share.
   b. Everyone.





Worksheet 6 (MC questions)

1 = c	11 = c and d	21 = c and d	31 = c
2 = d	12 = d	22 = b and c	32 = b
3 = a and c	13 = c	23 = b and c	33 = a
4 = b and c	14 = d	24 = c	34 = a, b and c
5 = c	15 = b	25 = c	35 = c
6 = d	16 = a	26 = a	36 = c
7 = d	17 = b and d	27 = d	37 = b
8 = c	18 = a and c	28 = d	38 = b
9 = b and d	19 = d	29 = c and d	39 = c and d
10 = c and d	20 = a and c	30 = d	40 = a and b

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