Candidate Handbook answers

Activity 6.1, p. 240

1. A coil of 65 μH is connected to a variable frequency a.c. source. The frequency is switched initially to 40 Hz and then to 60 Hz. What is the range of inductive reactance?

   0.016–0.02 Ω

2. If the coil in Question 1 is changed to a 2.4 H coil, what is the new range of inductive reactance?

   603.19–904.78 Ω

3. If a coil with an inductance of 26 mH has an inductive reactance 3.4 Ω, what is the frequency of the supply?

   20.81 Hz

4. What frequency is required to cause a 35 mH coil to have a reactance of 300 Ω?

   $f = X_L/(2\Pi L) = 1364.19$ Hz

5. If a 50 mH coil is connected to a variable frequency supply and the reactance ranges from 31.42 Ω to 47.12 Ω, what is the approximate frequency range?

   100–150 Hz

Activity 6.2, p. 241

1. A 24 μF capacitor is connected to a 50 Hz supply. What is the capacitive reactance?

   132.63 Ω

2. A capacitive circuit measures a reactance of 50 Ω when the supply frequency is turned to 150 Hz. What is the value of the capacitor?

   21.22 μF

3. What frequency is the supply if a 64 μF capacitor gives a capacitive reactance of 12 Ω?

   207.23 Hz

4. A 2.4 μF capacitor is added to a circuit with a 50 Hz supply. What capacitive reactance can be expected?

   1.33 MΩ

5. A capacitor of 10 μF and 20 μF are placed in parallel to a 30 Hz supply – what is the total reactance of the circuit?

   $X_c = 176.84$ Ω

Progress check 6.1, p. 243

1. In an inductive circuit, does the current lead or lag the voltage?

   The current lags the voltage.

2. In a capacitive circuit, does the current lead or lag the voltage?

   The current leads the voltage.

3. Explain the term ‘impedance’.

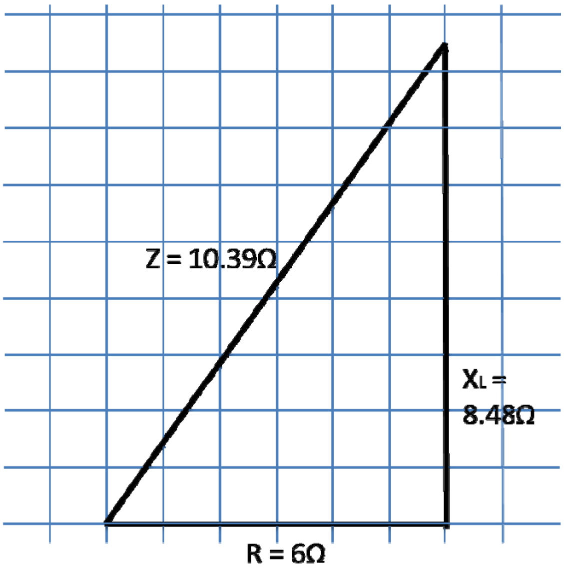
   The combined effect of capacitive and inductive reactance with resistance

Activity 6.3, p. 243

1. A 27 mH inductor is connected in series with a resistor of 6 Ω. The circuit is then connected to a supply frequency of 50 Hz. Find the circuit impedance by calculation.

   X_L = 8.48 Ω, Z = 10.39 Ω

2. For the circuit above, prove your calculation by scaled drawing.



3. A 350 mH inductor is connected to a series 100 Ω resistor. What is the circuit impedance if the supply is 50 Hz?

   209.96 Ω

Activity 6.4, p. 245

1. Explain what would happen if the coil was stretched out so it was no longer a coil but became a long conductor?

   The inductive reactance would disappear and the impedance would simply be the resistance, as the conductor would still have the same resistance.

2. What would be the new current?

   This would mean the current would be $\frac{230}{6}$

   = 38.3

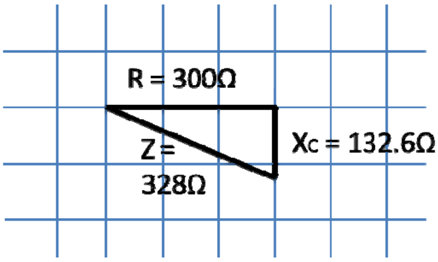
   a rise of nearly 3 A by removing the coil and back emf effect. This may also mean the wire would not be capable of carrying the new greater current and it would burn out or explode like a fuse.

Activity 6.5, p. 246

1. A 24 μf capacitor is connected in series with a resistor of 300 Ω. The circuit is then connected to a supply frequency of 50 Hz. Find the circuit impedance by calculation.

   X_c = 132.6 Ω, Z = $\sqrt{(300^2 + 132.6^2)}$ = 328Ω

2. Now prove your calculations by completing a scale drawing of an impedance triangle. Remember, at this level you should now be able to work with scales.



Progress check 6.2, p. 247

1. What is inductive reactance?

   A coil or any component that contains a winding of wire will behave in a different way when connected to an a.c. supply instead of d.c. This inductive effect causes a back emf and induces a current that opposes the main current generating it.

   There are several factors that can influence the amount of opposition to current flow. The reaction of a coil to an a.c. current is called inductive reactance.

2. What is capacitive reactance?

   As with inductors in an a.c. circuit, capacitors also have an effect on current flow.

   Capacitors have the opposite effect to inductors and this can actually be very useful. Capacitors in an a.c. circuit will have an inverse relationship with frequency – as frequency goes up, capacitive reactance (the opposition to current flow in a capacitive a.c. circuit) will go down. Capacitive reactance will also go down as the capacitance of the circuit increases. The formula to calculate capacitive reactance is shown below.

   $$X_c = \frac{1}{2\pi f C}$$

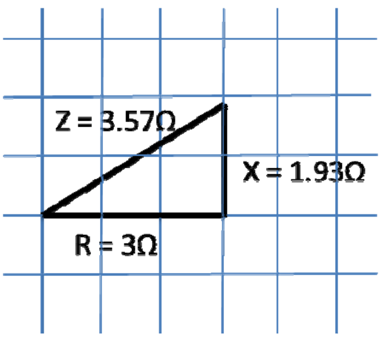
3. What is impedance?

   An a.c. circuit has more than one of these reactive components present at any one time. There is also a strong possibility that all three components will exist: capacitive, inductive and resistive. If this is the case, there must be an overall effect that is a combination of reactance. This overall effect is called impedance, as current flow is impeded.

Activity 6.6, p. 248

1. A 640 μF capacitor is connected in series with a resistor of 3 Ω and a 22 mH inductor. The circuit is then connected to a supply frequency of 50 Hz. Find the circuit impedance by calculation and then prove it by completing a scale drawing of an impedance triangle.

   X_c = 4.97 Ω, X_L = 6.9 Ω, Z = 3.57 Ω



2. A 240µF capacitor is connected in series with a 50 Ω resistor and a 20 mH inductor. What is the overall impedance of the circuit if the frequency is 50 Hz?

   X_c = 13.26 Ω, X_L = 6.28, Z = 50.48 Ω. This circuit is capacitive.

3. If the frequency is changed to 100 Hz in Question 2 and the resistor is replaced with a 10 Ω resistor, what is the new circuit impedance?

   X_c = 6.63 Ω, X_L = 12.57 Ω, Z = 11.63 Ω. This circuit is inductive.

4. An inductor of 12 Ω is connected in a series circuit with a capacitor of 159 µF and a 5.6 Ω resistor and a 3.9 Ω resistor. Assume the frequency is 50 Hz and calculate the circuit impedance.

   R_t = 9.5 Ω, X_c = 20 Ω, X_L = 12 Ω, Z = 12.42 Ω

5. What is the supply frequency if a resistive/capacitive series circuit has an overall impedance of 55.9 Ω? The resistor is 50 Ω and the capacitor is 25 µF.

   $$\mathbf{X_c = \sqrt{(Z^2 - R^2)} = 25\,\Omega}$$

   $$\mathbf{f = \frac{1}{2\pi \times X_c \times C} = 254.65\ Hz}$$

6. A series a.c. circuit contains a 10 Ω resistor, 12 Ω capacitive reactance and an inductor with reactance of 6.9 Ω. Calculate:

   - the total impedance
   - the current in the circuit if the voltage supply is 400 V.

   Z = 11.23, I = 35.62

Progress check 6.3, p. 252

1. What type of power is there in a purely resistive circuit?

   Active power

2. What is true power measured in?

   Watts

3. What does the term power mean?

   The amount of energy used in time

Activity 6.7, p. 255

1. What is considered to be a perfect power factor?

   Unity

2. What is the power factor of a series inductive circuit containing a 16 Ω resistor and an impedance of 22 Ω?

   0.72, 43.34°

3. If this circuit is connected to a 230 V, 50 Hz supply, what capacitor could be added in parallel to the inductive circuit to improve PF to 0.98? (Hint – draw out the circuit and the phasor following the previous worked example.)

   Uncorrected supply current = 10.45 A; from drawing the corrected PF of 0.98, I_t is 7.8 A, meaning a capacitive current of 5.6 A is required.

   $$\mathbf{X_c = \frac{230}{5.6} = 41\,\Omega}$$

   $$\mathbf{C = \frac{1}{2\pi \times 50 \times 41} = 78\ Hz}$$

Progress check 6.4, p. 256

1. What does illuminance mean?

   It is the amount of light falling on an area.
2. Define luminous efficacy.

   Luminous efficacy is the ratio of luminous flux emitted by the light to the input power.
3. What is meant by luminous intensity?

   Luminous intensity, I, is the light power emitted by a light source.

Progress check 6.5, p. 257

1. Name three factors that can affect light levels in a room.

   Colour of the walls, height of the ceiling, dirt/dust levels
2. Explain the difference between maintenance factors and utilisation factors.

   Utilisation factors relate to the physical design of the room such as decoration, colours and height/shape of the room. Maintenance factors are related to the environment the lighting is placed in, such as dirty, dusty or hot rooms that can shorten the life of a luminaire.
3. What factor code is specifically about dirt and grime reducing a light's brightness?

   LMF

Activity 6.8, p. 257

1. Look around you and make a judgement about the maintenance factors for the lighting in your room.

   Answer at discretion of tutor
2. Research light maintenance factors using the Internet and summarise them in a short report (no more than 500 words).

   Answer at discretion of tutor

Activity 6.9, p. 259

1. A work light is 4 m directly above a table and has a luminous intensity of 1 500 cd. What is the illumination at the table surface?

   93.75 lux
2. A bulkhead light is 3.5 m directly above a cable duct and is giving off a luminous intensity of 375 cd. What is the illumination at the cable duct?

   30.61 lux

Progress check 6.6, p. 261

1. What is a reasonable light level for a general maintenance workbench?

   200–400 lux
2. Describe how you would work out the light level directly under a luminaire.

   Use the inverse square law.

3. Describe how you would work out the light level a distance to the side of a luminaire.
   Use the cosine law.

Activity 6.10, p. 261

1. What is the illuminance if you are standing at point B in Figure 6.19? The light source has a luminous intensity of 2 300 cd. The angle between the 4 680 mm hypotenuse and the adjacent is 30°.

   90.94 lux
2. What is the illumination directly under the light in Question 1?

   d = cosØ x hyp = 4.05 m, E = 121.44 lux

Progress check 6.7, p. 262

1. What does maintenance factor mean?

   Lights are installed and stay in the same position for a number of years. The environment will affect their performance. If a room is very dirty or dusty this will settle on the lamp and the walls. The light performance will also gradually deteriorate with age – the light will burn less brightly. The conditions in the room might also shorten the life of the lamp and cause it to blow earlier, e.g. a machine room.
2. What does utilisation factor mean?

   Utilisation factor determines the illumination efficiency of a room and is affected by the colours, height of the ceiling and the type of luminaires. An average value is given as 0.6.
3. What is the formula for calculating the number of luminaires in a square room?

$$\mathbf{N = \frac{E \times A}{F \times n \times MF \times UF}}$$

Activity 6.11, p. 262

A 20 m by 10 m workshop requires lighting. The typical average light level (illuminance) required at the workbench is 300 lux. How many luminaire fittings will be required when each luminaire contains four fluorescent tubes? You can assume the maintenance factor is average at 0.6 and the utilisation factor is also average due to the room colour and ceiling tiles being whitewashed but dirty, 0.65. Each lamp is 2300 cd.

16.72 or approximately 17 luminaires

Progress check 6.8, p. 266

1. Describe briefly how an incandescent lamp works.

   Visible light is produced by current passing through fine gauge tungsten filament coils. The coils are wound into a coil and then the coils are further wound to make them more efficient. As the tungsten heats up, a reaction happens and some of the tungsten evaporates, moving to the inside wall of the glass envelope, turning the inside darker. Over a period of time evaporation causes the filament to wear thin. Eventually the filament will fail just like a fuse.
2. Describe why you should not handle a halogen lamp with bare hands.

   The grease will cause the quartz to crack.

Activity 6.12, p. 266

1. Using the Internet, search manufacturer websites and download data sheets for a GU10 lamp. Justify which GU10 you would choose based on the data.

   Answer at discretion of tutor

2. Investigate different household lamp applications (life span, power rating, lumens and cost) and make a comparison list for the most common types.

   Answer at discretion of tutor

Progress check 6.9, p. 269

1. What is the main advantage of a metal halide lamp over a high pressure mercury lamp?

   More efficient

2. What is the code given to high pressure mercury lamps by manufacturers?

   MBF

Activity 6.13, p. 269

Write a risk assessment for changing a high pressure sodium floodlight in a high bay warehouse.

Answer at discretion of tutor

Activity 6.14, p. 271

Find a plug-in lamp, safely turn it off at the socket, unplug it using gloves if it is hot (or wait 10 minutes for it to cool off) and then take the bulb out either by unscrewing or push/twist and release. Find a data sheet for this particular lamp on the Internet and make your own notes on the lamp, including power rating, lumens, energy rating and the type of fitting. Create your own data sheet to give to a customer explaining the main features.

Answer at discretion of tutor

Progress check 6.10, p. 271

1. Describe luminous intensity.

   Luminous intensity (I) – the light power emitted by a light source in a particular direction. It is measured in candelas. A candle emits roughly one candela of light.

2. What is the formula for illumination directly under a light source?

   $$\mathbf{E = \frac{I}{d^2}}$$

3. What is the formula for illumination at a point to the side of the source?

   $$\mathbf{E = \frac{(I \times \cos\theta)}{d^2}}$$

4. Draw the circuit for a low pressure mercury lamp and label all the parts.

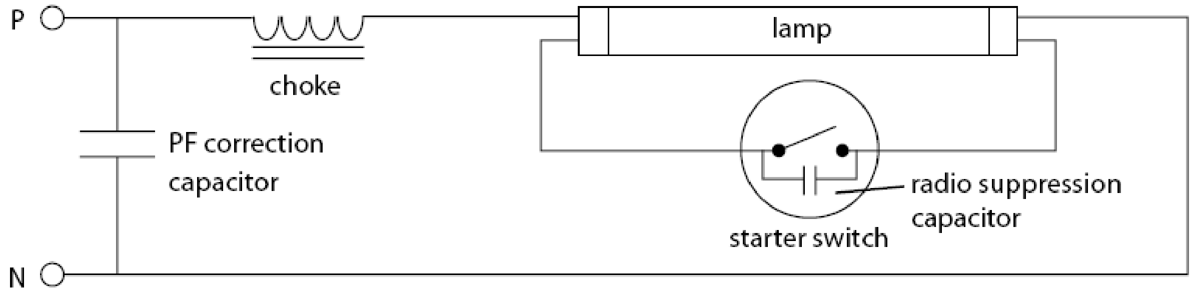


Figure 6.31: Glow-type starter circuit

5. Describe how a fluorescent luminaire starts.

The current passes through to one end of the lamp which heats up the cathode filament. Heating the tungsten filament excites the electrons creating an electron cloud at the cathode. The current then passes through to the starter switch. This switch is contained in a glass bulb and is made of bimetallic strips that heat up and bend towards each other. The reason current passes through from one contact to another in the starter switch is the partially conductive helium gas. A glow discharge happens around the bimetallic contacts. To complete the conductive path, the current passes through the switch contact and on to the other cathode at the far end of the tube before continuing on to the neutral.

Back at the starter switch, the partially conductive helium gas allows the current to pass from contact to contact within the starter bulb. As this occurs the bimetallic contacts heat up and bend to each other until they touch. The conductive helium gas causes a glow in the starter. As they touch they go from being a high resistance path to a very low resistance path. As they fully touch, the bimetallic strips cool down rapidly. The rapid cooling makes the bimetallic strips spring apart very quickly, which causes the magnetic field to collapse in the coil of the choke. A collapsing magnetic field will create a large back emf (voltage). This large voltage is dropped across the two cathodes which is enough to encourage the already excited electrons at the cathodes to bridge the gap and create a fully conductive path. As the discharge happens from one end of the tube to the other, the gases warm up and the path becomes less resistive. If there is less resistance, more current is able to flow from cathode to cathode. The choke therefore has a second function – one of a current limiter. If this whole process does not strike the tube, it will be repeated until it lights up.

Once the light has fully struck, visible light is created by the photons given off in the conductive tube reacting with the phosphorous coating inside the tube wall.

6. Name five different luminaire types.

See table below.

7. Describe the main advantages and disadvantages of each.

See table below.

Lamp type	*Advantages*	*Disadvantages*
GLS	• Cheap • No control gear required • Fairly good colour rendering • Can operate in any position • Lots of colours and styles	• Rated life only 1,000 hours • Poor efficacy (14 lm/w)

Lamp type	***Advantages***	***Disadvantages***
Tungsten halogen	• Cheap • No control gear required • Good colour rendering • Good power range	• Efficacy of 20 lm/w • Cannot be handled without cleaning • Can get very hot
Low pressure mercury	• Cheap • Long life •	• Special disposal required • Contains mercury • Several failure points in circuit • Requires starting gear • Requires power factor correction
High pressure mercury	• More efficient than low pressure mercury • Good colour rendering	• Special disposal required • Contains mercury • Expensive
High pressure sodium	• Warm light • Long life	• Expensive • Sodium is hygroscopic • Special disposal required

8. Describe an application for each type of light system.

   GLS – domestic light

   Tungsten halogen – display, flood, indoor growing

   Low pressure mercury – commercial lighting

   High pressure mercury – industrial lighting/roads

   High pressure sodium – floodlight/road light

Working practice 6.1, p. 271

A large college has noticed that over the past two years their electricity bills have risen faster than expected and more than the advertised rates. They call in a specialist to investigate where all the electricity is being used as the onsite maintenance team has not been able to solve the problem. The electrical contractors notice there is a very high volume of fluorescent lights. All of the fluorescent tubes are changed when they blow by the maintenance team and the number of lights and plug-in electrical equipment has not changed significantly over the past few years.

1. What could be the problem?

   Bad power factor

2. How could this be proved?

   Calculate the expected current based on the loads and then measure the current drawn at the supply and compare.

3. What could be the solution?

   Replace the power factor capacitors in the fluorescent tube circuits.

Activity 6.15, p. 274

1. A star connected network has a line voltage of 6.35 kV and a line current of 100 A. Find the following values by calculation if the power factor is 0.7:
   - the phase current

     100 A
   - the phase voltage

     3.67 kV
   - the power.

     445 kW
2. A star connected network has a line voltage of 65 kV and a phase current of 600 A. Find the following values by calculation if the power factor angle is 32°:
   - the phase current

     600 A
   - the phase voltage

     37.53 kV
   - the power.

     33.07 MW

   Now find the values by calculation if the power factor changes to 0.7.

   The only change is the power. P = 47.28 MW
3. An unbalanced star connected network has the following line currents: line 1 = 13 A, line 2 = 13 A and line 3 = 5 A.

   What is the current flowing in the neutral? Show by phasor diagram using an appropriate scale.

   Appropriate phasor diagram with a 10 A gap to represent the neutral current

Progress check 6.11, p. 276

1. How many different currents and voltages are there in a star network?

   1 current, 2 voltages
2. How many different currents and voltages are there in a delta network?

   2 currents, 1 voltage
3. What is the formula for power in both star and delta networks?

   $P = \sqrt{3} \times V_L \times I_L \times \cos\theta$

Activity 6.16, p. 276

1. A delta connected network has a power factor angle of 25° and a line voltage of 750 V. If the line current is 100 A, find the following by calculation:

   a) the phase voltage

   750 V

   b) the phase current

   57.74 A

   c) the power.

   117.7 kW

2. A delta network has a phase voltage of 400 V, a phase current of 95 A and a power factor angle of 12°. Calculate the following:

a) the line voltage

400 V

b) the line current

164.5 A

c) the power.

111.48 kW

Activity 6.17, p. 279

1. A star network has three identical phase loads. One phase has a resistance of 55 Ω and an inductor of 38 mH operating at 50 Hz. If the line voltage is 175 V, calculate:

a) the inductive reactance

11.94 Ω

b) the impedance

56.28 Ω

c) the power factor

0.977

d) the line current

1.8 A

e) the phase current

1.8 A

f) the phase voltage

101.04 V

g) the power.

533 W

2. A delta network has three identical phase loads. One phase has a resistance of 15 Ω and an inductor of 12.7 mH operating at 60 Hz. If the line voltage is 200 V, calculate:

a) the inductive reactance

4.79 Ω

b) the impedance

15.75 Ω

c) the power factor

0.95

d) the line current

22 A

e) the phase current

12.7 A

f) the phase voltage

200 V

g) the power.

7.24 kW

Progress check 6.12, p. 282

1. Describe how a commutator works.

   The supply is connected to the moving commutator and the armature loops via static carbon brushes. The carbon brushes maintain contact with the commutator by a spring-loaded housing pushing them onto the copper commutator. As the commutator rotates, it slides against the brushes but electrical contact is maintained. Now imagine the loop is approaching the vertical position – this is the point at which ideally you want the supply to change direction. The loop has just enough momentum to keep moving and this pushes the commutator round past the insulated strip between the two commutator segments. The supply effectively switches direction and the flux lines around the conductor reverse – the forces are now the same as the first phase when the rotation started.

2. Why is carbon a good material for a motor brush?

   The carbon brushes have several advantages. Carbon has a negative temperature coefficient. This means as the brushes heat up with friction, the resistance decreases and they perform better from an electrical view point. Carbon also acts as a self-lubricant allowing the commutator to slide easily.

3. What is the outer case that holds the pole pairs called?

   Yoke

Progress check 6.13, p. 284

1. How do you control the speed of a d.c. series motor?

   Speed control of a d.c. series motor is achieved by varying the strength of the magnetic field. A variable resistor is connected across the field winding and this diverts some of the current.

2. Why should a series d.c. motor never be connected up to a load by a belt drive?

   Because if it breaks the motor will speed up until it self-destructs.

3. What is one method of starting a large d.c. motor?

   A d.c. faceplate starter

Progress check 6.14, p. 285

1. What does ‘shunt’ actually mean?

   Parallel

2. What is a shunt motor also known as?

   A constant speed d.c. motor

3. How is speed control achieved on a shunt motor?

   A variable resistor

Progress check 6.15, p. 291

1. What is rotor speed?

   The speed at which the motor actually turns

2. What is synchronous speed and how do you work it out?

   It is the speed at which the three-phase magnetic field moves around the stator and is found by the following formula:

$$N_S = \frac{\text{Frequency}}{\text{No. of magnetic pole pairs}}$$

3. What is slip and how do you work it out?

   Slip is the difference between the rotor and synchronous speed and is found by the following formula:

$$\text{Percentage slip} = \frac{N_s - N_r}{N_s} \times 100$$

Activity 6.18, p. 291

1. Find the synchronous speed of a four pole motor that is connected to a 50 Hz supply.
   25 Hz
2. For the motor in Question 1, what is the synchronous speed in revolutions per minute?
   1500 rpm
3. A six pole motor has a slip of 5% when connected to a 60 Hz supply. Calculate the synchronous speed of the three-phase motor and the rotor speed in revolutions per second.

   Synchronous speed is 20, rotor speed is 19

Progress check 6.16, p. 297

1. Define the capacitor's function in a capacitor start induction motor.

   The capacitor creates a phase shift between the start and run winding.
2. What does the second capacitor do in a capacitor start, capacitor run induction motor?
   Power factor correction to bring the current in phase with the supply voltage once started, to improve efficiency

Progress check 6.17, p. 303

1. What method is used to start a wound rotor a.c. motor?

   External resistors and slip rings
2. What is a simple way to explain star delta starters?

   First and second gear on a car
3. What does no volt protection do?

   Prevent accidental restart when voltage supply drops below a certain level

Progress check 6.18, p. 304

1. How do you identify the polarity of a solenoid?

   Right-hand grip rule
2. Explain briefly how a DOL contactor starts a three-phase motor.

   A solenoid is activated by a small start current that then switches over contactors to allow the larger current to pass through.

Progress check 6.19, p. 304

1. Describe the two methods by which an MCB operates when a fault occurs.

   Thermal and magnetic

2. Describe how the trip coil is activated in an RCD.

   As long as the current on the line matches the current on the neutral, the induced magnetism in the toroid core cancels each other out. If, however, there is a slight leakage to earth (a contact between the live and earth) there will be an imbalance in the two coils. This imbalance will mean the induced magnetic flux will not be the same on both sides of the core and a third coil that sits between the line and neutral coil will detect a new generated magnetic flux. This search coil will trip a relay and cut the circuit off instantly, making it safe.

3. Describe four different types of protective device and the different applications they are suitable for.

   RCD – sockets

   HRC – circuits with very high fault currents

   MCB type B – domestic standard usage

   MCB type C – circuits with higher start-up currents

   MCB type D – very high inductive loads such as X-rays

Progress check 6.20, p. 310

1. Describe what the motorised valves are used for on a Y plan.

   A valve is like a diode. Water must flow through in the direction of the arrow on the side of the valve when it has been activated.

2. How many motorised valves are there on a Y plan? Describe what they do.

   The system consists of a three-port mid-position valve. This means the control system can provide independent switching of water and heating circuits. The thermostats and the mid-position diverter valve work together to ensure the pump and boiler only come on when they are needed. This level of control ensures energy is not wasted by overheating the water or radiators.

3. Describe the difference between convection and radiant heaters.

   A convection heater will heat a space by causing a thermal current to flow in the room. A radiant heater will heat whatever object is placed directly in front of it. A radiant heater will not raise the temperature of a room unless it is left on for a long time.

4. Describe how a thermostat operates.

   A thermostat is a device that switches when a certain pre-determined temperature is reached. Bimetallic strips made of two metals with different expansion coefficients are bonded together. As the temperature rises, the two metal strips expand at different rates. If the bonded metals expand at different rates, the net effect is they will bend one way or the other. This action will make or break a contact and therefore act as a switch, sending a signal to the heating system.

Activity 6.19, p. 314

1. Gather a selection of resistors and use the colour code to work out the actual values and tolerance levels. Put the results in a table of your own design for the task.

   Answer at discretion of tutor

2. Choose and set an ohmmeter to the correct range for your first resistor. Measure the resistor and decide if it is within the permitted range. Complete this for all the selected resistors and present your findings in a table of results.

   Answer at discretion of tutor

Progress check 6.21, p. 318

1. Write down the resistor colour codes and associated values.

   Black 0, brown 1, red 2, orange 3, yellow 4, green 5, blue 6, violet 7, grey 8, white 9
2. Write down the colour code for the tolerance bands and the associated values.

   No band 20%, silver 10%, gold 5%, red 2%, brown 1%

3. Describe briefly in your own words another method of identifying a resistor without colours, using an example.

   Resistors can also have code letters and numbers, e.g. 5k5 is 5,500 Ω
4. Describe briefly the applications of different types of variable resistors.

   Linear track can be used on a mixing desk, rotary variable resistors used for tuning circuits, LDRs used in light sensing applications such as security lights

Activity 6.20, p. 318

1. A resistor reads: red, orange, green with a tolerance band of brown. What is the resistor value and acceptable range?

   2.3 MΩ +/- 1%
2. A resistor reads: yellow, violet, orange, brown. What is the resistor and the operating range?

   47 kΩ +/- 1%
3. A resistor body is marked 3M4M. What is the actual value?

   3.4 MΩ +/- 20%

Progress check 6.22, p. 334

1. Describe how an a.c. supply can be converted to d.c. using electronic components.

   Via a four-diode bridge rectifier and smoothing capacitors
2. Name three applications for capacitors.

   Radio frequency suppression, power factor correction and rectification smoothing
3. Describe how to work out a resistor value from a colour code by creating an example.
   The first colour gives the first digit. The second colour gives the second digit. The third colour gives the amount of '0s' to be added and the last separate band gives the tolerance. Red, red, orange, brown will give: 2 2 000 +/- 1%.

Progress check 6.23, p. 335

1. Describe three areas where a building services engineer might require some knowledge of electronic components.

   Fire alarm circuits, security circuits, lighting control, building management systems

2. Explain the function of diacs in a dimmer circuit.

   The diac acts as a switch for the triac.

3. What is the function of a triac in a lighting control?

   The triac allows current to flow through to the load light when triggered.

Knowledge check, p. 336

1. The current in a coil changes from 5.4 A to 2 A in 0.04 seconds and induces a voltage of 20 V. What is the inductance of the coil?

   c 0.24 H

2. A circuit consists of two series resistors of 5 Ω and 3 Ω. What is the power in the 3 Ω resistor if the circuit current is 3 A?

   a 36 W

3. A series network is made up of a capacitor of reactance 50 Ω, resistor of 40 Ω and inductor of 80 Ω. What is the power factor of the circuit?

   d 0.8

4. A luminaire producing a luminous intensity of 1 000 cd is installed 4 m above a surface. What is the illuminance on that surface directly beneath?

   a 62.5 lux

5. In a four wire balanced three-phase system, the line current is 40 A. What is the neutral current?

   c 0 A

6. The supply is connected to the rotor of a three-phase wound rotor induction motor by what method?

   b Slip rings and brushes

7. A current-carrying conductor is placed at right angles to a permanent magnetic field. The movement that follows can be described as what?

   d The motor effect

8. A four pole three-phase induction motor with 4% slip is connected to a 400 V, 50 Hz supply. What is the rotor speed?

   a 24 revs/s

9. What method is used to start a d.c. motor?

   c A faceplate starter

10. The no-volt circuit in a DOL starter is designed to do what?

    b Prevent starting after loss of supply

11. The centre part of a solenoid is known as what?

    c The former

12. An infrared heater is an example of what type of heater?

    c Radiant

13. A Y plan heating system consists of what components?

    b Three-port mid-position valve

14. If the capacitors used in the networks in the diagram [below] are all 3 μF, which network will give an overall capacitance of 4 μF?

    a A

15. A residual current device will operate under what conditions?

    d Phase to CPC fault