



# Candidate Handbook answers

## Activity 1.1, p. 3

1. If a charge of 180 C flows in a luminaire every 2 minutes, what is the current?

$$I = \frac{180}{120} = 1.5 \text{ A}$$

2. What is the charge in coulombs if a current of 3.2 A flows for 2 seconds?

$$Q = It, \text{ rearranged from } I = \frac{Q}{t}, \text{ so } Q = 3.2 \times 2 = 6.4 \text{ C}$$

## Progress check 1.1, p. 9

1. What does the symbol prefix 'm' mean?  
**Milli or  $\times 10^{-3}$**
2. What does the prefix ' $\mu$ ' mean?  
**Micro or  $\times 10^{-6}$**
3. What is the base unit for weight?  
**Newton**

## Activity 1.2, p. 9

1. Convert 0.0048 F into a number with a prefix.  
**4.8 mF,  $4.8 \times 10^{-3}$  F**
2. Convert 4.5 mF into a number without a prefix.  
**0.0045 F**
3. Show 1.2 TN as MN.  
**1 200 000  $\times 10^6$  or 1 200 000 MN**
4. Change 64  $\mu$ F into mf.  
**0.064  $\times 10^{-3}$  or 0.064 mf**
5. Represent 0.000 000 135 A as mA.  
**0.000 135  $\times 10^{-3}$  A or 0.000 135 mA**

## Activity 1.3, p. 11

1.  $(9 + 7) \times 1 + 3 = 19$
2.  $(4 + 4 - 3 + 1)^2 + 3 + 3 = 42$
3.  $(7 + 8) \div 3 + 3 = 8$
4.  $(7 + 7 \times 7) \times (3 + 3) = 336$



### Activity 1.4, p. 14

1. The opposite is 33 m and the hypotenuse is 80 m – what is the angle?  
**24.36°**
2. The adjacent is 49 mm and the angle is 60° – how long is the hypotenuse?  
**98 mm**
3. The hypotenuse is 1 km and the angle is 24° – how long is the adjacent?  
**913.5 m**

### Activity 1.5, p. 15

Work out the resistance of the following conductors:

1. a 25 m length of 2.5 mm<sup>2</sup> copper  
**0.175 Ω**
2. 400 m of 1.5 mm<sup>2</sup> copper  
**4.67 Ω**
3. 50 m of 8 mm<sup>2</sup> aluminium  
**0.176 Ω**
4. 25 m of 6 mm<sup>2</sup> copper  
**0.073 Ω**
5. 100 m of 1 mm<sup>2</sup> copper earth conductor.  
**1.75 Ω**

### Activity 1.6, p. 20

For each of the five examples below, calculate:

- the total resistance
  - the total circuit current
  - the voltage drop across each resistor.
1. A series circuit has three resistors:  $R_1 = 3\ \Omega$ ,  $R_2 = 6\ \Omega$ ,  $R_3 = 9\ \Omega$  and is connected across a 12 V supply.  
 **$R_t = 18\ \Omega$ ,  $I_t = 0.67\ \text{A}$ ,  $V_1 = 2\ \text{V}$ ,  $V_2 = 4\ \text{V}$ ,  $V_3 = 6\ \text{V}$**
  2. A series circuit has four resistors:  $R_1 = 1.2\ \Omega$ ,  $R_2 = 2.6\ \Omega$ ,  $R_3 = 9\ \Omega$ ,  $R_4 = 9\ \Omega$  and is connected across a 24 V supply.  
 **$R_t = 21.8\ \Omega$ ,  $I_t = 1.1\ \text{A}$ ,  $V_1 = 1.32\ \text{V}$ ,  $V_2 = 2.86\ \text{V}$ ,  $V_3 = 9.9\ \text{V}$ ,  $V_4 = 9.9\ \text{V}$**
  3. A series circuit has five resistors:  $R_1 = 12\ \Omega$ ,  $R_2 = 36\ \Omega$ ,  $R_3 = 29\ \Omega$ ,  $R_4 = 5\ \Omega$ ,  $R_5 = 6\ \Omega$  and is connected across a 36 V supply.  
 **$R_t = 88\ \Omega$ ,  $I_t = 0.41\ \text{A}$ ,  $V_1 = 4.92\ \text{V}$ ,  $V_2 = 14.76\ \text{V}$ ,  $V_3 = 11.89\ \text{V}$ ,  $V_4 = 2.05\ \text{V}$ ,  $V_5 = 2.46\ \text{V}$**
  4. A series circuit has four resistors:  $R_1 = 2\ \text{k}\Omega$ ,  $R_2 = 3\ \text{k}\Omega$ ,  $R_3 = 6.7\ \text{k}\Omega$ ,  $R_4 = 5\ \text{k}\Omega$ , and is connected across a 230 V supply.  
 **$R_t = 16.7\ \text{k}\Omega$ ,  $I_t = 13.77\ \text{mA}$ ,  $V_1 = 27.5\ \text{V}$ ,  $V_2 = 41.31\ \text{V}$ ,  $V_3 = 92.26\ \text{V}$ ,  $V_4 = 68.85\ \text{V}$**

5. A series circuit has four resistors:  $R_1 = 1.7 \text{ M}\Omega$ ,  $R_2 = 2.3 \text{ M}\Omega$ ,  $R_3 = 2.9 \text{ M}\Omega$ ,  $R_4 = 5.7 \text{ M}\Omega$  and is connected across a 400 V supply.

**$R_t = 12.6 \text{ M}\Omega$ ,  $I_t = 31.75 \text{ }\mu\text{A}$ ,  $V_1 = 53.98 \text{ V}$ ,  $V_2 = 73.03 \text{ V}$ ,  $V_3 = 92.08 \text{ V}$ ,  $V_4 = 180.98 \text{ V}$**

### Activity 1.7, p. 22

1. A parallel circuit consists of two resistors:  $R_1 = 2.4 \text{ }\Omega$  and  $R_2 = 1.2 \text{ }\Omega$ . If they are connected to a 12 V supply, calculate:
  - (a) the total resistance
  - (b) the total circuit current
  - (c) the current in each resistor.

**(a)  $0.8 \text{ }\Omega$  (b) 15 A (c) 5 A, 10 A**
2. The circuit in Question 1 has a third resistor connected in parallel of  $5.9 \text{ }\Omega$ . Carry out the same calculations and find:
  - (a) the total resistance
  - (b) the new total circuit current
  - (c) the current in each of the three legs.

**(a)  $0.7 \text{ }\Omega$  (b) 17.03 A (c) 5 A, 10 A, 2.03 A**
3. A parallel circuit consists of four resistors:  $R_1 = 4 \text{ }\Omega$ ,  $R_2 = 1.8 \text{ }\Omega$ ,  $R_3 = 3.7 \text{ }\Omega$  and  $R_4 = 6.7 \text{ }\Omega$ . If they are connected to a 24 V supply, calculate:
  - (a) the total resistance
  - (b) the total circuit current
  - (c) the current in each resistor.

**(a)  $0.82 \text{ }\Omega$  (b) 29.4 A (c) 6 A, 13.33 A, 6.49 A, 3.58 A**
4. The circuit in Question 3 has a fifth resistor connected in parallel of  $12.3 \text{ }\Omega$  and the voltage supply is changed for 40 V. Carry out the same calculations and find:
  - (a) the total resistance
  - (b) the new total circuit current
  - (c) the current in each of the five legs.

**(a)  $0.77 \text{ }\Omega$  (b) 52.25 A (c) 10 A, 22.22 A, 10.81 A, 5.97 A, 3.25 A**
5. The circuit consists of four resistors connected in parallel. If  $R_1 = 12 \text{ }\Omega$ ,  $R_2 = R_1 + 20\%$ ,  $R_3 = R_2 + 20\%$ ,  $R_4 = R_3 + 20\%$  and if the circuit is connected to a 36 V supply, calculate and find:
  - (a) the individual resistor values
  - (b) the total resistance
  - (c) the total circuit current
  - (d) the current in each of the four legs.

**(a) 12  $\Omega$ , 14.4  $\Omega$ , 17.28  $\Omega$ , 20.736  $\Omega$  (b) 3.86  $\Omega$  (c) 9.32 A (d) 3 A, 2.5 A, 2.08 vA, 1.74 A**

## Activity 1.8, p. 23

For Questions 1 and 2 below, calculate:

- the total circuit resistance
  - the total circuit current
  - the voltage drop across each resistor in the network.
1. A parallel resistor network containing four equal  $4\ \Omega$  resistors is connected to a fifth series resistor,  $R_5$ , with a resistance of  $12\ \Omega$ . If the whole circuit is connected across a  $12\ \text{V}$  supply, carry out the calculations above.  
 $R_t = 13\ \Omega$ ,  $I_t = 0.923\ \text{A}$ ,  $V_5 = 11.1\ \text{V}$ ,  $V_{1-4} = 0.9\ \text{V}$
  2. The same circuit as Question 1 has all five resistors replaced with  $3\ \Omega$  resistors and the supply is changed to  $24\ \text{V}$ . Carry out the calculations above.  
 $R_t = 3.75\ \Omega$ ,  $I_t = 6.4\ \text{A}$ ,  $V_5 = 19.2\ \text{V}$ ,  $V_{1-4} = 4.8\ \text{V}$

## Activity 1.9, p. 24

1. Calculate the power if a  $100\ \text{m}\Omega$  resistor is connected to a  $36\ \text{V}$  supply.  
 $12.96\ \text{kW}$ ,  $P = \frac{V^2}{R}$
2. What is the resistor value if the power is  $10.2\ \text{W}$  when a current of  $3.9\ \text{A}$  passes through it?  
 $671\ \text{m}\Omega$ ,  $R = \frac{P}{I^2}$
3. If the voltage across a  $1.2\ \text{k}\Omega$  resistor is  $210\ \text{V}$ , what is the power dissipated?  
 $36.75\ \text{W}$ ,  $P = \frac{V^2}{R}$
4. A voltmeter registers  $125\ \text{V}$  across a resistor and an ammeter reads  $30\ \text{A}$ . What is the power dissipated in the resistor?  
 $3.75\ \text{kW}$ ,  $P = VI$
5. What is the voltage drop across a  $15\ \Omega$  resistor when the power measures  $120\ \text{W}$ ?  
 $42.43\ \text{V}$ ,  $V = \sqrt{(PR)}$

## Activity 1.10, p. 31

1. What cross-sectional area does a magnet need to have to produce a magnetic flux density of  $5\ \text{T}$  when the magnetic flux is  $5\ \text{Wb}$ ?  
 $A = \frac{\Phi}{B} = 1\ \text{m}^2$
2. What is the magnetic flux density of a magnet with a cross-sectional area of  $0.3\ \text{m}^2$  and a flux of  $4\ \text{Wb}$ ?  
 $B = \frac{\Phi}{A} = \frac{4}{0.3} = 13.33\ \text{T}$



3. What is the magnetic flux of a 160 mT magnet with a cross-sectional area of 200 mm<sup>2</sup>?

$$\phi = B \times A, \phi = 160 \times 10^{-3} \times 200 \times 10^{-6}$$

$$= 32 \mu\text{Wb}$$

4. A magnet of flux 120  $\mu\text{Wb}$  and cross-sectional area 200 mm<sup>2</sup> is required to have a flux density of 1 T to be used as a fire door magnet. Is this magnet strong enough to hold the fire door open?

**No, this would give a flux density of 0.6 T.**

5. A motor requires a magnet with a flux density of 0.65 T. If the flux is 200 mWb, what is the cross-sectional area of the magnet?

$$A = 0.31 \text{ m}^2$$

### Activity 1.11, p. 35

1. Calculate how long a conductor is when placed inside a 4 T magnetic pole pair. A force of 6 N is experienced when the current is 20.9 mA.

$$L = \frac{F}{(BI)} = \frac{6}{(4 \times 20.9 \times 10^{-3})} = 71.77 \text{ m}$$

2. What force will a 0.6 m conductor experience if it has a 3 mA current flowing through it and is placed in a 5 T magnetic flux?

$$F = BIL = 5 \times 3 \times 10^{-3} \times 0.6 = 9 \text{ mN}$$

3. Calculate the magnetic flux density of a 22 m current-carrying conductor that is carrying a current of 2 A and experiences a force of 3 N.

$$B = \frac{F}{(IL)} = \frac{3}{(2 \times 22)} = 0.068 \text{ T}$$

4. What current is flowing in a conductive armature of 0.3 m length when it experiences a force of 0.68 N when moving through a 2 T magnetic field?

$$I = \frac{F}{(BL)} = \frac{0.68}{(2 \times 0.3)} = 1.13 \text{ A}$$

5. How long does a conductor need to be to experience a force of 3 N when a current of 250 mA passes through it? The magnetic flux density is 350 mT.

$$L = \frac{F}{(BI)} = \frac{3}{(0.35 \times 0.25)} = 34.29 \text{ m}$$

### Activity 1.12, p. 37

1. A 0.2 m long conductor moves through a magnetic field of density 12.3 T at a velocity of 1800 cm/minute. Calculate the emf induced in the conductor.

$$E = 12.3 \times 0.2 \times 0.3 = 0.738 \text{ V}$$

2. A conductor is moved through a magnetic field of flux density 200 mT at a velocity of 18 000 mm/minute. The conductor is twice the length of the conductor in the previous question. What emf is generated?

$$E = 200 \times 10^{-3} \times 0.4 \times 0.3 = 0.024 \text{ V}$$

3. What is the velocity of a 15 m conductor that generates 230 V when moved through a 15 T magnetic field?

$$V = \frac{E}{(Bl)} = \frac{230}{(15 \times 15)} = 1.02 \text{ rev/s}$$

4. What speed is required to generate a voltage of 210 V when the generator components consist of an armature of 12 m and a magnet of flux density 2.1 T?

$$V = \frac{E}{(Bl)} = \frac{210}{(2.1 \times 12)} = 8.33 \text{ rev/s}$$

5. A voltage of 120 V is required from a generator with an armature of length 13 m and that has a maximum velocity capability of 10 rev/s. What size magnet is required?

$$B = \frac{E}{(Vl)} = \frac{120}{(13 \times 10)} = 0.923 \text{ T}$$

### Activity 1.13, p. 39

1. If a wave form has a period of 50  $\mu\text{s}$ , what is the frequency? (Don't forget to take great care with the units and convert to base values.)

$$f = \frac{1}{50 \times 10^{-6}} = 20 \text{ KHz}$$

2. If one third of a full sine wave cycle is 33 mS, what is the frequency?

$$3 \times 33 \text{ mS} = 99 \text{ mS}, 0.01 \text{ Hz}$$

3. A square wave reaches its maximum value of 3 V twice in 20 mS. What is the frequency of this square wave?

$$f = \frac{1}{20 \times 10^{-3}} = 50 \text{ Hz}$$

4. A 100 GHz signal is measured on an oscilloscope. What is the length of one cycle?

$$T = \frac{1}{f} = \frac{1}{100 \times 10^9} = 10 \times 10^{-12} \text{ or } 10 \text{ pS}$$

5. If a sine wave has a frequency range 10–12 kHz, what is the period range?

$$T = \frac{1}{f}, 100 \mu\text{S} - 83.3 \mu\text{S}$$

### Activity 1.14, p. 47

1. A transformer has a primary voltage of 230 V and a secondary of 12 V. If the primary turns are 200, how many turns are there on the secondary side?

$$N_s = N_p \times \frac{V_s}{V_p} = 10.4$$

2. A core transformer has 3 A at the output and is supplied by 12 A, 400 V. What is the secondary voltage?

$$V_s = V_p \times \frac{I_p}{I_s} = 1600 \text{ V}$$



3. A shell transformer has a turns ration of 20: 1 and a secondary voltage of 23 V. What is the primary voltage?

$$V_p = 20 \times \frac{23}{1} = 460 \text{ V}$$

4. A transformer is supplied with 200 V at 3 A. If the secondary current is 15 A, what is the secondary voltage?

$$V_s = I_p \times \frac{V_p}{I_s} = 40 \text{ V}$$

### Progress check 1.2, p. 49

1. How do you calculate the energy stored in a coil?

$$\frac{1}{2} LI^2$$

2. Define inductance in a coil.

**The property of a coil to resist current flow is a measure of a coil's inductance, L, and is measured in henrys.**

3. What is the transformer formula?

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{I_s}{I_p}$$

### Activity 1.15, p. 50

1. What is the force due to gravity on a control panel with a mass of 15 kg?

$$147.15 \text{ N}$$

2. What is the mass of a cable drum with a weight force of 108.2 N?

$$11.03 \text{ kg}$$

3. How many cable drums of mass 27 kg each can a trolley rated at 1 kN carry in one trip?

$$3 \text{ drums}$$

### Activity 1.16, p. 50

1. What energy do you use when moving a street light from a highways depot store to your van? It requires a force of 16 N and the distance is 25 m.

$$W = 16 \times 25 = 400 \text{ J}$$

2. What energy is required when loading your van with three cable drums? Each drum takes 10 N of force and the distance is 10 m.

$$W = 3 \times (10 \times 10) = 300 \text{ N}$$

3. How far do you move if the total work done moving your site lockup box is 2500 J and the force used is 3 N?

$$d = \frac{W}{f} = \frac{2500}{3} = 833.3 \text{ m}$$



4. What energy will be spent moving a 200 kg transformer core 12 m into position for installation?  
 $F = mg$ ,  $F = 200 \times 9.81 = 1962 \text{ N}$ ,  $W = Fd$ ,  $W = 1962 \times 12 = 23.544 \text{ kJ}$
5. What energy will be used moving 7 x 25 kg photovoltaic panels 20 m from the delivery pallet to winch position?  
 $F = mg$ ,  $F = 7 \times 25 \times 9.81 = 1716.75 \text{ N}$ ,  $W = Fd = 1716.75 \times 20 = 34.335 \text{ kJ}$

### Activity 1.17, p. 51

1. Calculate the potential energy of a cable drum that has a mass of 50 kg and which is to be lifted 0.75 m into the back of a truck.  
 $PE = mgh$ ,  $PE = 50 \times 9.81 \times 0.75 = 367.88 \text{ J}$
2. Calculate the height a cable tray has been lifted if the potential energy is 1 kJ and the mass is 20 kg.  

$$h = \frac{PE}{(mg)} = \frac{1000}{(20 \times 9.81)} = 5.1 \text{ m}$$
3. Calculate the mass of a tool chest that has a potential energy of 250 J and requires lifting 1.75 m back on to the store shelf.  

$$m = \frac{PE}{(gh)} = \frac{250}{(9.81 \times 1.75)} = 14.56 \text{ kg}$$
4. Calculate the potential energy of a pallet of solar panels with a mass of 100 kg to be lifted on to a roof at a height of 6 m.  
 $PE = mgh = 100 \times 9.81 \times 6 = 5.886 \text{ kJ}$
5. A control panel for a motor is to be lifted up a 30 m riser. The control panel is labelled up as 2000 N. What is the potential energy of the control panel?  
 $PE = mgh = 2000 \times 30 = 60 \text{ kJ}$

### Activity 1.18, p. 52

1. How much power will you use if you move a 50 kg crate of stripped copper 50 m to the recycling bin in 5 minutes?  
 $F = 490.5 \text{ N}$ ,  $W = 24\,525 \text{ J}$ ,  $P = 81.75 \text{ W}$
2. You use 500 kJ of energy moving a fluorescent bulb crushing machine from the tailgate of a delivery truck to your electrical storage area which is 75 m away and it takes you half an hour. How much does it weigh?  

$$F = \frac{W}{d} = 6.6666 \text{ kN}$$

$$m = \frac{F}{g} = \frac{6666.67}{9.81} = 680 \text{ kg}$$
3. How much power will you use if you move a conduit bending machine (mass of 20 kg) a distance of 30 m in 30 seconds?  
 $F = 196.2 \text{ N}$ ,  $W = 5886 \text{ J}$ 

$$P = \frac{W}{t} = \frac{5886}{30} = 196.2 \text{ W}$$



4. How much power will you use moving a pallet of contactors with a mass of 78 kg from your van to the installation position 12.5 m away in 2 minutes?

$$W = Fd, W = 78 \times 9.81 \times 12.5 = 9564.75 \text{ J}$$

$$P = \frac{W}{t} = \frac{9564.75}{120} = 79.71 \text{ W}$$

5. You need to move a ground source heat pump 35 m from your secure lockup to the installation point. The pump weighs 75 kg and you have 20 minutes to do the task. How much power will you exert doing the move?

$$W = 75 \times 9.81 \times 35 = 25\,751.25 \text{ J}$$

$$P = \frac{25751.25}{1200} = 21.46 \text{ W}$$

### Activity 1.19, p. 54

1. A first order lever is used to raise a motor off the ground. The lever is 2.75 m long and you are 1.9 m from the fulcrum. The motor is 200 kg. What force will you exert?

$$F_2 = 200 \times 9.81 = 1962 \text{ N}, D_2 = 2.75 - 1.9 = 0.85 \text{ m}$$

$$F_1 = \frac{F_2 \times D_2}{D_1} = \frac{1962 \times 0.85}{1.9} = 877.7 \text{ N}$$

2. The same scenario as Question 1, but this time the motor has increased to 300 kg. How much force will be required now?

$$F_2 = 300 \times 9.81 = 2943 \text{ N}$$

$$F_1 = \frac{2943 \times 0.85}{1.9} = 1316.6 \text{ N}$$

### Activity 1.20, p. 56

1. A machine has losses of 3.1 kW and it requires 56 kW to run. What is the required input power?

$$\text{Input power} = \text{output power} + \text{losses} = 3.1 + 56 = 59.1 \text{ kW}$$

2. What is the efficiency of the above machine?

$$\text{Efficiency} = \frac{P_o}{P_i} = \frac{56}{59.1} \times 100\% = 94.75\%$$

3. If the same machine is serviced and the overall efficiency improves by 1%, what is the new input power required?

$$\text{Efficiency} = 95.75\%$$

$$P_i = \frac{56}{0.9575} = 58.49 \text{ kW}$$

4. A motor is 97.3% efficient and produces 16.7 kW of output power. What input power is required to achieve this?

$$P_i = \frac{P_o}{0.973} = 17.16 \text{ kW}$$

5. A d.c. motor has a loss of 3.1 kW due to vibration and friction. If the input power is 22 kW, what is the efficiency of the motor?

$$P_o = P_i - \text{loss} = 18.9 \text{ kW}$$

$$\text{Efficiency} = \frac{P_o}{P_i} = \frac{18.9}{22} = 0.859 \text{ or } 85.9\%$$

### Progress check 1.3, p. 59

1. Define what effect a capacitor and inductor will have on an a.c. circuit.  
**A capacitor will cause a current to lead voltage and an inductor will make current lag voltage in an a.c. circuit.**
2. What is impedance?  
**This is the combined effect of capacitors, inductors and resistance in an a.c. circuit.**
3. What is power factor and why does it need correction?  
**Power factor is the relationship between current and voltage in an a.c. circuit. The farther out of phase they are from each other, the less efficient the circuit will be, which is why it needs to be corrected.**

### Progress check 1.4, p. 63

1. What happens if a three-phase supply is not balanced?  
**The neutral will carry the balance of the out of phase current, heat up and possibly fail.**
2. Draw and label a star network.

#### Star connection

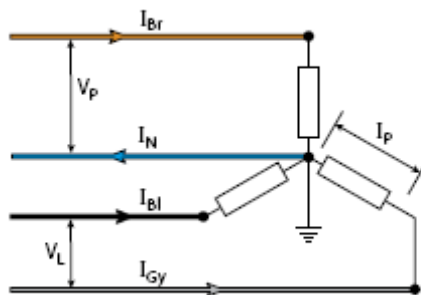


Figure 1.64: Star connection

3. Draw and label a delta network.

#### Delta connection

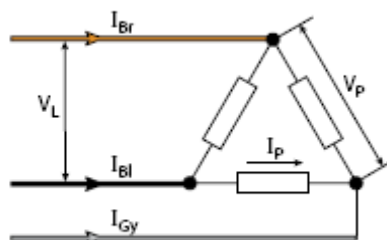


Figure 1.63: Delta connection

## Knowledge check, p. 64

1. What is the unit for magnetic flux density?  
**b T**
2. 34 000 000 J can also be written as what?  
**a 34 MJ**
3.  $7^2 \times (3 \times 3 + 3)$  can be simplified to what?  
**c 588**
4. If copper has a resistivity of  $17.5 \times 10^{-9}$ , what is the resistance of a 25 m length of  $2.5 \text{ mm}^2$  conductor?  
**b 0.175  $\Omega$**
5. What is the resistance of a series circuit with resistors of 3  $\Omega$ , 6  $\Omega$ , 9  $\Omega$ ?  
**d 18  $\Omega$**
6. A parallel circuit consists of two resistors:  $R_1 = 2.5 \Omega$ ,  $R_2 = 1.2 \Omega$ . If the circuit is connected to a 12 V supply, what is the total circuit current?  
**d 15 A**
7. A parallel circuit has four resistors of 1.7 M $\Omega$ , 2.3 M $\Omega$ , 2.9 M $\Omega$ , 5.7 M $\Omega$ . This parallel circuit is now connected to a 400 V supply. What is the total circuit current drawn by the loads?  
**d 0.617 mA**
8. What is the magnetic flux density of a magnet with a cross-sectional area of  $0.3 \text{ m}^2$  and a flux of 4 Wb?  
**a 13.33 T**
9. A 280 kg mass is suspended by four ropes on a moveable pulley system. What is the mechanical advantage?  
**c 4**
10. What force will a 0.6 m conductor experience if it has a 3 mA current flowing through it when placed in a 5 T magnetic field?  
**c 0.009 T**
11. A sine wave reaches the same peak value twice in 50 mS. What is the frequency of the sine wave?  
**d 20 Hz**
12. What energy has been used moving a 200 kg transformer core 12 m into position for installation?  
**a 23.544 kJ**
13. A motor is 97.3% efficient and produces 16.7 kW of power at its output. What input power is required to achieve this?  
**c 17.16 kW**
14. What is the best power factor?  
**a Unity**
15. A transformer has a turns ration of 3 : 1 and a secondary current of 3 A. What is its primary current?  
**d 1 A**