Insight Publications

INSIGHT

Trial Exam Paper

2008
PHYSICS
Written examination 1

Worked solutions

This book presents:

- worked solutions, giving you a series of points to show you how to work through the questions.
- mark allocation details
- tips and guidelines

SECTION A – Core

Area of study 1 – Motion in one and two dimensions

The following information applies to Questions 1 and 2.

Jimmy is running to catch a bus, but he has to go around the house on the corner. The dotted line represents Jimmy's path. The path lengths are allocated as shown in Figure 1. It takes him 20 seconds to reach the bus.

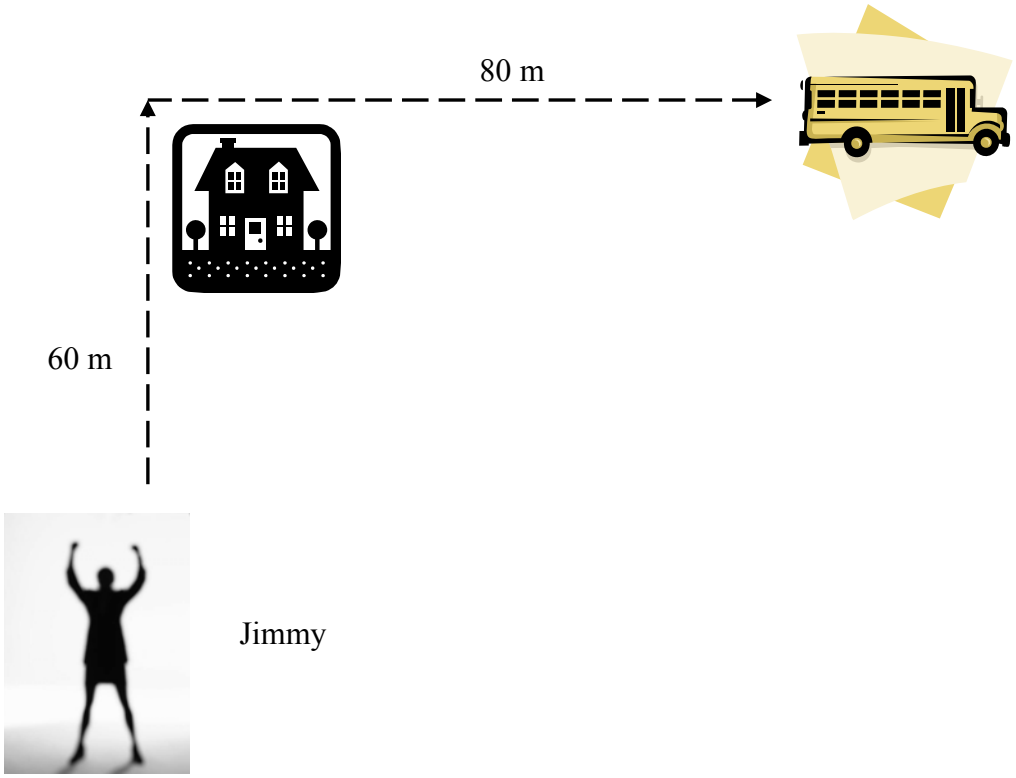


Figure 1

Question 1

Find Jimmy's average speed.

Worked solution

$$\text{Speed} = \frac{\text{Dis tan ce}}{\text{Time}}$$

$$= \frac{140\text{ m}}{20\text{ s}}$$

$$= 7\text{ ms}^{-1}$$

7 ms^{-1}

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 2

Find the magnitude of Jimmy's average velocity.

Worked solution

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$
$$= \frac{\sqrt{80^2 + 60^2}}{20}$$
$$= \frac{100 \text{ m}}{20 \text{ s}}$$
$$= 5 \text{ ms}^{-1}$$

5 ms^{-1}

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

The following information applies to Questions 3 and 4.

Sarah is practising her sprint starts for the 2008 Olympics. She is accelerating over 70 metres from a static start, and this takes her 10 seconds. Assume that her acceleration is constant.

Question 3

What is Sarah's acceleration during her drills?

Worked solution

$$s = 70$$
$$u = 0$$
$$t = 10$$
$$a = ?$$
$$s = ut + 0.5at^2$$
$$70 = 0 + 0.5a(10)^2$$
$$a = \frac{70}{50}$$
$$= 1.4 \text{ ms}^{-2}$$

1.4 ms^{-2}

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 4

At what velocity is Sarah running when she passes the 40-metre mark?

Worked solution

$v = ?$

$s = 40$

$a = 1.4$

$u = 0$

$v^2 = u^2 + 2as$

$v^2 = 0 + 2(1.4)(40)$

$= 112$

$v = \sqrt{112}$

$= 10.58 \text{ ms}^{-1}$

10.58 ms^{-1}

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

The following information applies to Questions 5–8.

Gussy is travelling at 20 ms^{-1} while riding his bike to Physics class when he realises he has left his books at home. He needs to do a U-turn, and fast! But he realises that the maximum friction between the bike and his tyres will be 3200 N. Gussy's speed remains at 20 ms^{-1} throughout the turn, and the total mass of Gussy and his bike is 80 kg. This is shown in Figure 2.

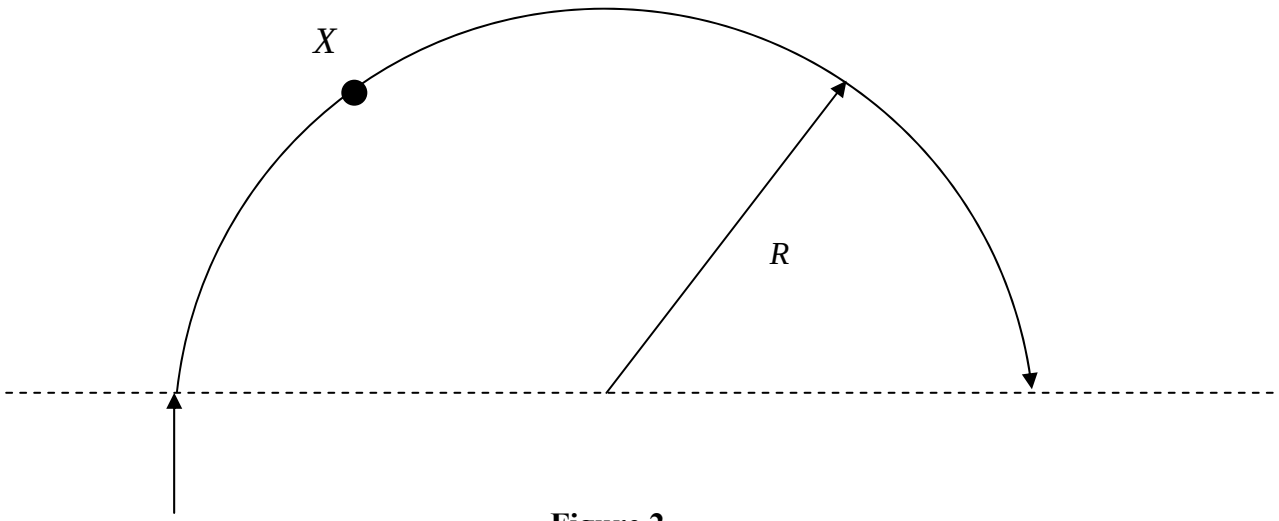


Figure 2

Question 5

Calculate the radius of Gussy's turning circle, *R*, if he is to stay on his bike.

Worked solution

$$F = \frac{mv^2}{R}$$

$$R = \frac{mv^2}{F}$$

$$= \frac{80 \times 20^2}{3200}$$

$$= 10 \text{ m}$$

10 m

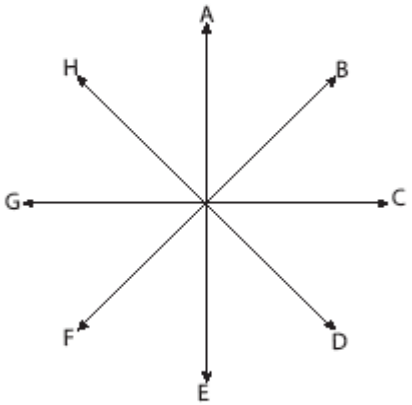
2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 6

At point *X*, which is the closest direction to the net force on Gussy? Choose from:



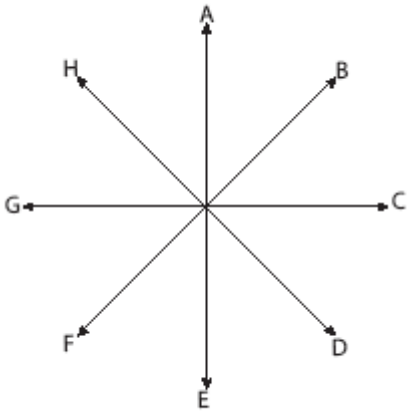
Worked solution
Net force is always towards the centre of the circle.

D

2 marks

Question 7

At point *X*, which is the closest direction to Gussy's velocity? Choose from:



Worked solution
The direction of the velocity is along the tangent at *X*.

B

2 marks

Question 8

Which of the following is the best estimate of the magnitude of Gussy's **change** in momentum?

A. 0 kg ms^{-1}
B. 80 × 20 kg ms^{-1}
C. 2 × 80 × 20 kg ms^{-1}
D. –80 × 20 kg ms^{-1}

Worked solution

Initial momentum is 80 × 20 kg ms^{-1}, then final momentum is 80 × 20 kg ms^{-1} **in the opposite direction**.

C

2 marks

Sammi, a 70 kg skier, is flying down a 40° slope with an acceleration of 5 ms^{-2}. He realises that there must be some retarding force upon him.

Question 9

Find the force opposing Sammi's progress.

Worked solution

Sammi force pulling him down the slope.

$F = ma$
$= 70 \times 5$
$= 350$ N (1 mark)

Force pulling Sammi down the slope due to gravity.

$F = mg \sin \theta$
$= 70 \times 10 \times \sin(40°)$
$= 449.95$ N
$= 450$ N (1 mark)

Force opposing motion = 450 – 350
= 100 N (1 mark)

100 N

3 marks

Mark allocation

- 1 mark for correctly calculating Sammi's own force pulling him down the slope.
- 1 mark for correctly calculating force pulling Sammi down the slope due to gravity.
- 1 mark for correctly calculating opposing motion.

The following information applies to Questions 10–12.

Paulke is punting a football. He initially kicks it with a speed of 45 ms^{-1}, and the ball goes 50 m high, as shown in Figure 3.

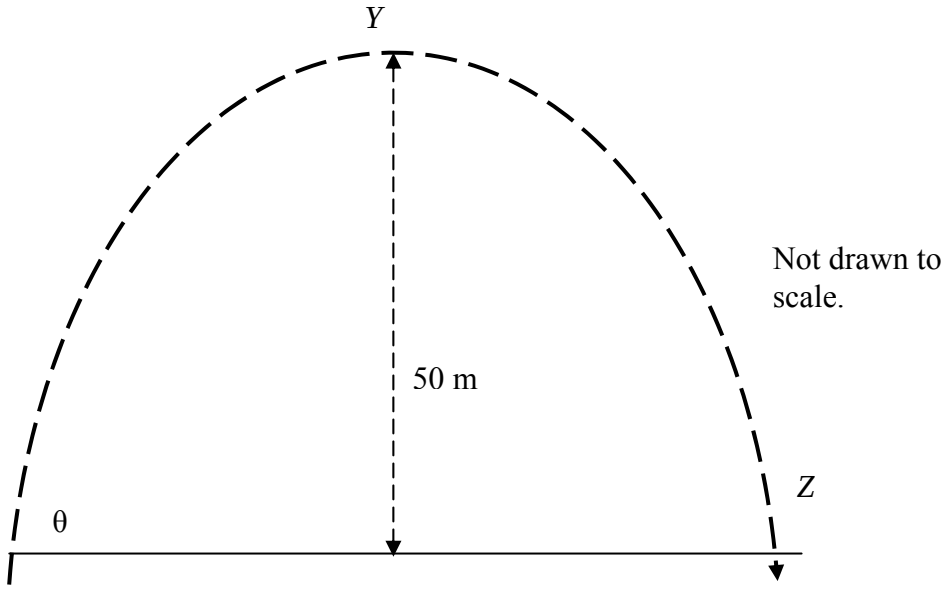


Figure 3

Question 10

Calculate the vertical velocity of the ball as it leaves Paulke's foot.

Worked solution

First, need to find vertical velocity.

$u = ?$

$v = 0$

$s = 50$

$a = -10$

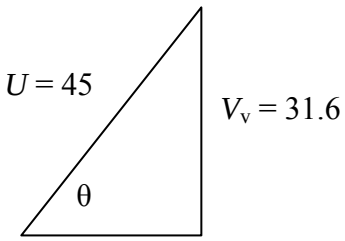
$v^2 = u^2 + 2as$

$0 = u^2 - 2(10)(50)$

$u^2 = 1000$

$u = 31.6 \text{ ms}^{-1}$

Now use vectors to calculate the angle, θ, that the ball makes with the horizontal as it leaves Paulke's foot. Workings should include appropriate vector diagrams.



$\sin^{-1} \theta = \dfrac{31.6}{45}$

$\theta = 44.6°$

44.6°

3 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for calculating vertical velocity.
- 1 mark for correct answer.

Question 11

In what direction is the acceleration of the ball at point *Y*, the highest point in the ball's flight?

A. zero
B. left
C. right
D. down

Worked solution

There is only acceleration due to gravity, which is always down.

D

2 marks

Question 12

In what direction is the acceleration of the ball at point *Z*, just before the ball hits the ground?

A zero
B left
C right
D down

Worked solution

There is only acceleration due to gravity, which is always down.

D

2 marks

A fat 2 kilogram cat is sunbaking in a tree when it has a nightmare and falls out! It falls 5 m, but is able to land on its feet and it takes 0.05 seconds to come to a stop. It then scampers back up the tree.

Question 13

What is the average force that the cat needs to exert against the ground to stop its fall in 0.05 seconds?

Worked solution

First, find speed of cat as it hits the ground.

$v^2 = u^2 + 2as$

$v^2 = 0 + 2(10)(5)$

$v^2 = 100$

$v = 10 \text{ ms}^{-1}$ (1 mark)

Impulse = Change in momentum

$= m\Delta v$

$= 2 \times 10$

$= 20 \text{ kg ms}^{-1}$ (1 mark)

Impulse = Force × Time

$20 = F \times 0.05$

$F = 400$ N (2 marks)

400 N

4 marks

Mark allocation

- 1 mark for correctly calculating speed of cat as it hits the ground.
- 1 mark for calculating change in momentum.
- 2 marks for correctly calculating the force needed by the cat.

Angus and Matilda are walking in the park, listening to music, and not taking much notice of where they are going. Angus is walking south at 5 ms^{-1}, and Matilda is walking west, also at 5 ms^{-1}.

Question 14

The relative velocity of Angus relative to Matilda is:

A. $\sqrt{50}$ ms^{-1} south–east
B. $\sqrt{50}$ ms^{-1} north–east
C. 5 ms^{-1} north–east
D. 5 ms^{-1} south–east

Worked solution

Use of Pythagoras' theorem gives a magnitude of $\sqrt{50}$ ms^{-1} and direction is south–east.

A

2 marks

The following information applies to Questions 15 and 16.

A satellite is orbiting the planet Saturn and its period is 11.86 hours.

Mass of Saturn = 5.685×10^{26} kg

Radius of Saturn = 60 268 km

Mass of Earth = 6.0×10^{24} kg

Radius of Earth = 6400 km

Question 15

What is the average radius of the satellite's orbit around Saturn?

Worked solution

T = 11.86 hours = 42 696 s (1 mark)

$$R^3 = \frac{GMT^2}{4\pi^2}$$

$$R^3 = \frac{6.67\times10^{-11}\times5.685\times10^{26}\times42\,696^2}{4\pi^2}$$ (1 mark)

$= 1.75 \times 10^{24}$

R = 120 536 000 metres (1 mark)

or

R = 120 536 km

Tip

Get $R^3 = \frac{GMT^2}{4\pi^2}$ *and other 'derived' formulas on your A4 sheet to save time in the exam.*

1.2×10^8 m

3 marks

Question 16

Which of the following gives the best value for the acceleration due to gravity at the 'surface' of Saturn?

A. 1000 ms^{-2}
B. 100 ms^{-2}
C. 10 ms^{-2}
D. 1 ms^{-2}

Worked solution

$g = GM/R^2$

Mass × 100 (approx.)

$R \times 10 : R^2 \times 100$ (approx.)

Mass/R^2 = 1 (approx.), or the same as Earth

C

2 marks

Jeremiah is setting up a tyre swing in the backyard of his house. He had designed it so there would be a 50 cm gap between the bottom of the tyre and the ground. But when he attached his 2 kg tyre to the rope, he noticed that there was only a 40 cm gap. He deduced that the rope had stretched when the tyre was placed on it, and that it behaves in an elastic manner.

Question 17

Find the force constant, *k*, for the rope. Include the unit.

Worked solution

$$k = \frac{F}{\Delta x}$$
$$= \frac{mg}{10\text{ cm}}$$
$$= \frac{2 \times 10}{0.1\text{ m}}$$
$$= 200\text{ Nm}^{-1}$$

200 Nm^{-1}

3 marks

Mark allocation

- 1 mark for finding change in distance and converting to metres.
- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

END OF AREA OF STUDY 1
SECTION A – continued

Area of study 2 – Electronics and photonics

The following information applies to Questions 1–3.

Allan and Beth have set up a simple circuit with four identical resistors to a 20 V power supply, as shown in Figure 1.

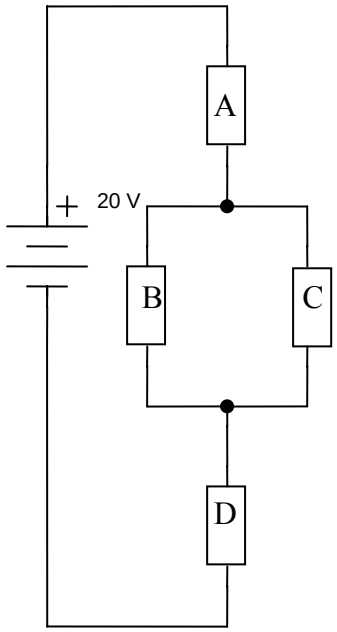


Figure 1

Question 1

If the resistance of each resistor is expressed as *R*, find the total resistance of the circuit in terms of *R*.

Worked solution and mark allocation

The parallel combination of B and C is worth 0.5 *R*. (1 mark)

Total resistance for circuit is A (*R*), + D (*R*), + B and C (0.5 *R*) = 2.5 *R* (1 mark)

2.5 *R*

2 marks

Question 2

Find the ratio of:

$$\frac{\text{Current through resistor A}}{\text{Current through resistor C}}$$

Worked solution

Any current that goes through A will split in half because resistors B and C are equal.

2 : 1

2 marks

Question 3

What is the voltage drop across resistor C?

Worked solution and mark allocation

The parallel combination of B and C is worth 0.5 *R*. Total resistance for circuit is 2.5 *R*.

$\frac{20}{2.5} = 8$

8 V across A.

8 V across D. (1 mark)

4 V drop across C. (1 mark)

4 V

2 marks

The following information relates to Questions 4 and 5.

The current–voltage characteristic of a LED is shown in Figure 2. It has a maximum voltage drop of 0.7 V.

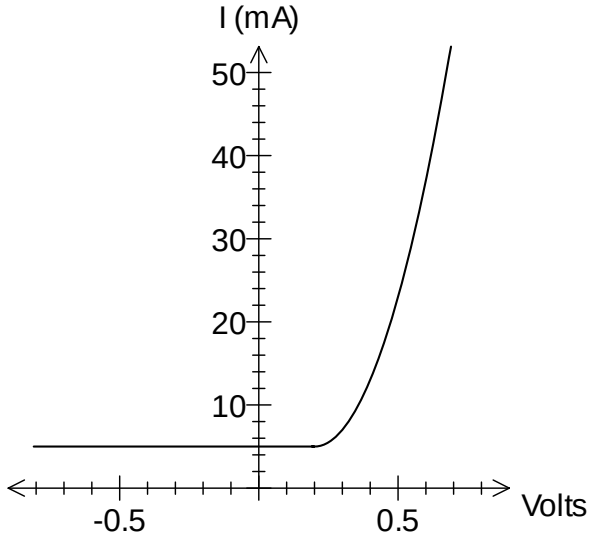


Figure 2

A LED is placed in a simple circuit with a resistor and a 3 V power supply, as shown in Figure 3.

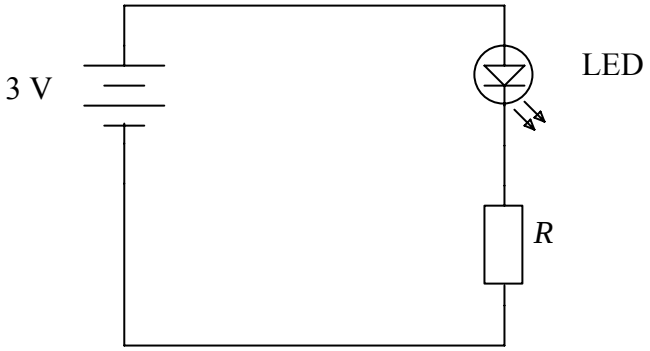


Figure 3

Question 4

If the ammeter reads 20 mA, what is the value of the resistor, *R*?

Worked solution

20 mA through the LED means it is drawing approximately 0.5 V. (i.e. 0.45 – 0.55 V)

This means there is a drop of 2.5 V across the resistor.

$$V = IR$$

$$R = \frac{V}{I}$$

$$= \frac{2.5}{20 \times 10^{-3}}$$

$$= 125\ \Omega$$

125 Ω

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 5

Two LEDs are now placed in a circuit with two 50 Ω resistors, as shown in Figure 4. The LEDs are of the same design as the one in Question 4.

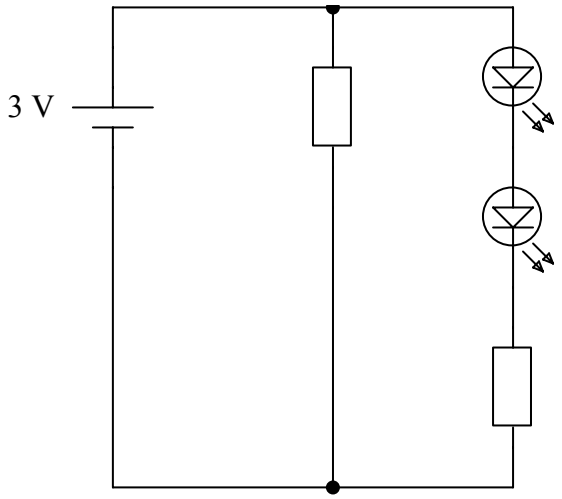


Figure 4

Calculate the current flowing through the LEDs. Express your answer in mA.

Worked solution

Two 0.7 V = 1.4 V drop over the two LEDs. (1 mark)

Leaves 3 V – 1.4 = 1.6 V drop over resistor in series with LED.

V = IR

$$I = \frac{V}{R}$$

$$= \frac{1.6}{50}$$

= 0.032 A

= 32 mA (1 mark)

32 mA

2 marks

Mark allocation

- 1 mark for calculating voltage drop correctly.
- 1 mark for correct answer.

The following information applies to Questions 6–8.

The graph of the resistance of an LDR with respect to the light intensity is shown below in Figure 5.

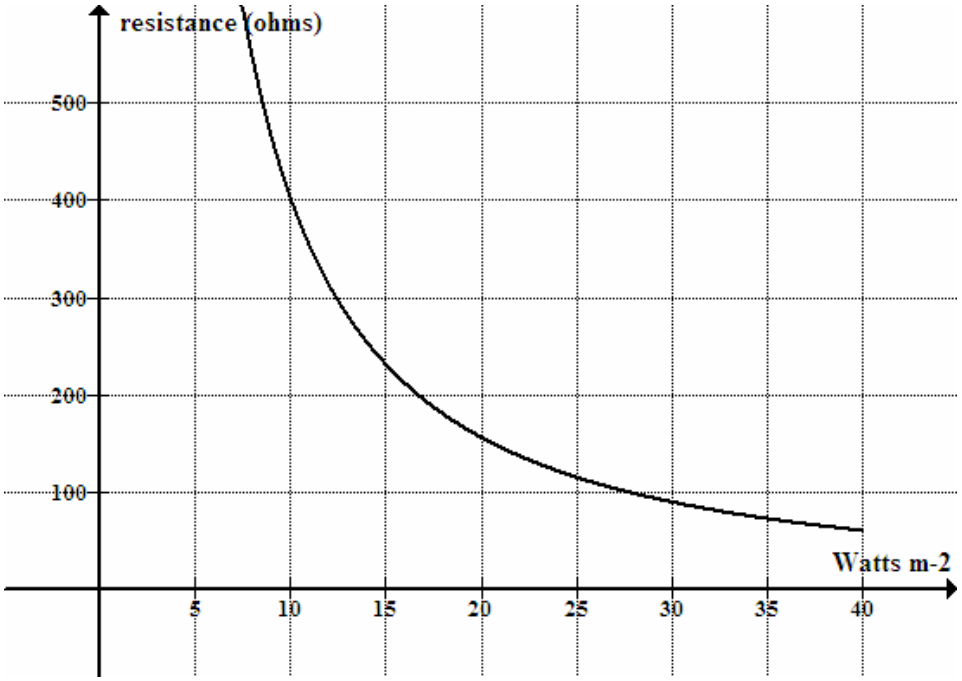


Figure 5

Question 6

What is the resistance of the LDR when the light intensity is at 10 watts m^{-2}?

Worked solution

Read from graph $R = 400\ \Omega$

400 Ω

1 mark

Mark allocation

- 1 mark for correct answer.

The LDR is placed in the circuit below in order to turn on the lights in a house at a specified light intensity, as shown in Figure 6.

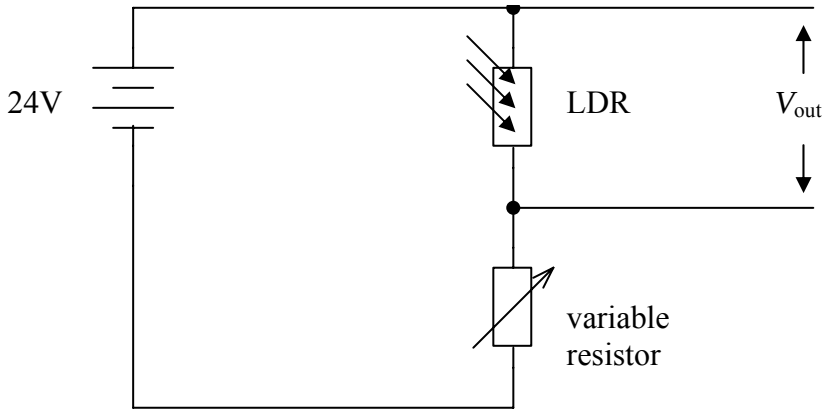


Figure 6

Question 7

The home owner requires the lights to turn on automatically when the light intensity is less than 10 watts m^{-2}. What is the value of the variable resistor if the required value of V_{out} is 16 V?

Worked solution

Resistance of LDR = 400 Ω and V across LDR = 16 V.

V across variable resistor = 8 V

$$V_{out} = \frac{R_1}{R_{total}} \times V_{in}$$

$$16 = \frac{400}{R_{total}} \times 24$$

$$R_{total} = \frac{400 \times 24}{16}$$

$$R_{total} = 600$$

$$V_{resistor} = 600 - 400$$

$$= 200\ \Omega$$

200 Ω

3 marks

Mark allocation

- 1 mark for correctly calculating total resistance = 600 Ω
- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer

The homeowner then turns the variable resistor to a higher value.

Question 8

Will this make the light come on earlier or later than before? Explain your answer.

Worked solution and mark allocation

With a higher variable resistor, it will take more of the available voltage. (1 mark)

Voltage across LDR will decrease; needs to be darker to increase voltage across the LDR to have V_{out} equal to 16 V, thus light comes on later. (1 mark)

OR

Will need an increase in the resistance of the LDR to keep the ratio of the two resistors equal (1 mark), therefore, it needs to be darker, thus light comes on later (1 mark).

2 marks

Question 9

Explain the operation of a photodiode.

Worked solution and mark allocation

A photodiode is reverse biased. (1 mark)

It allows current to flow when light strikes its surface. (1 mark)

2 marks

Question 10

Give two reasons why phototransistors may be used in place of photodiodes.

Worked solution and mark allocation

They are faster (1 mark) and more sensitive (1 mark).

2 marks

Question 11

An amplifier has the following characteristics, as shown in Figure 7a.

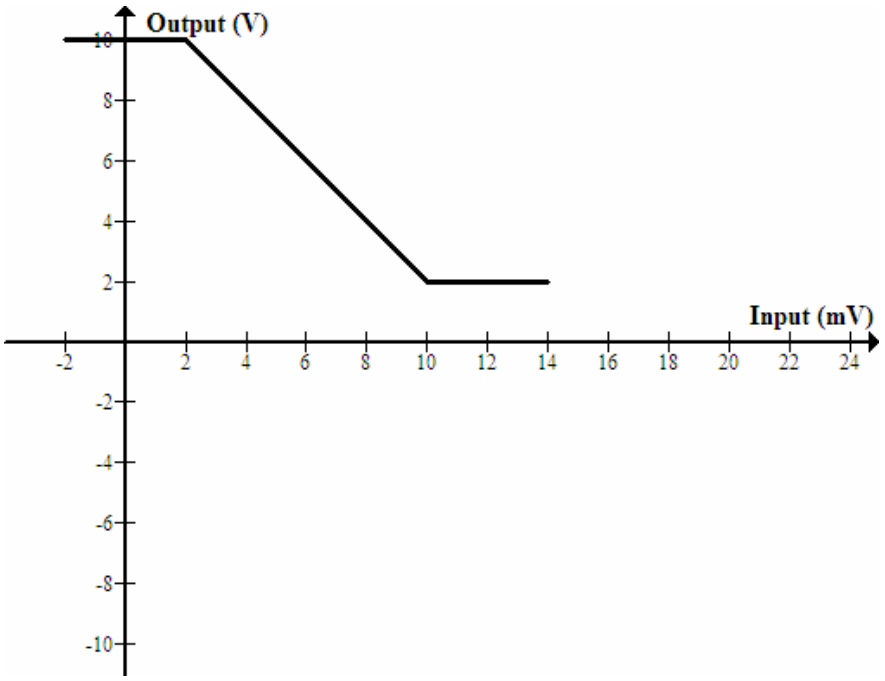


Figure 7a

An input of the following is put into the amplifier, as shown in Figure 7b.

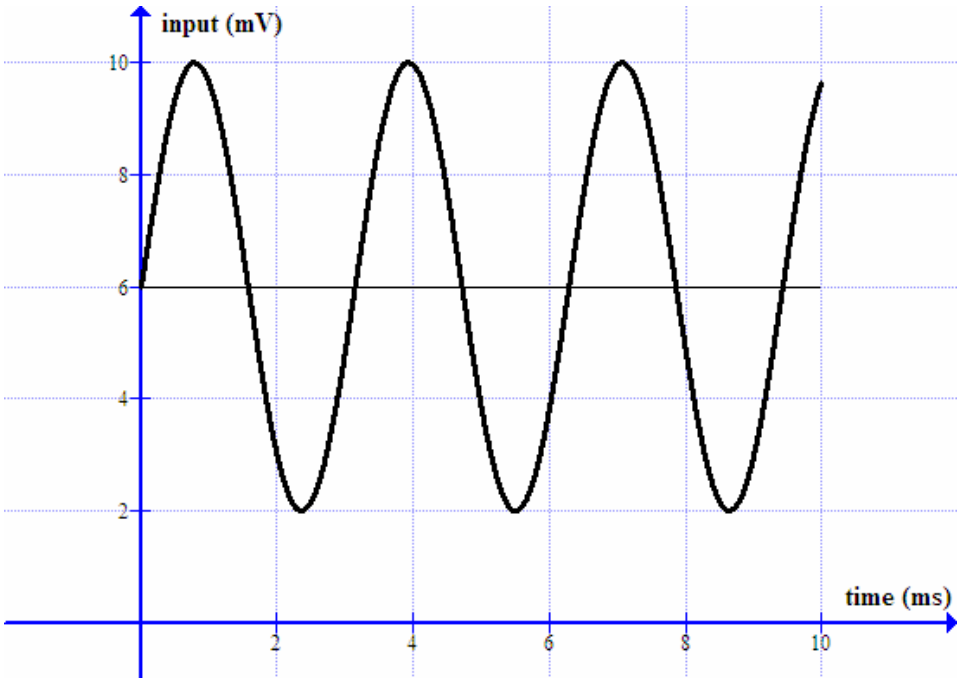
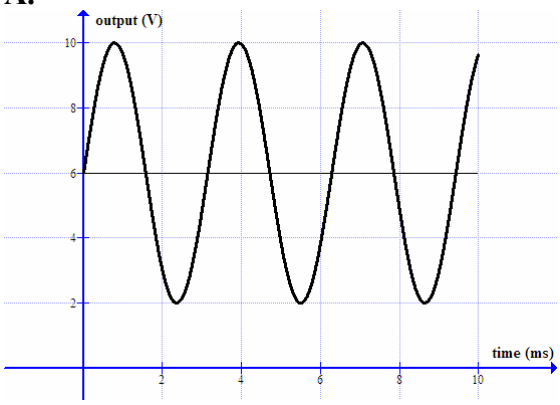


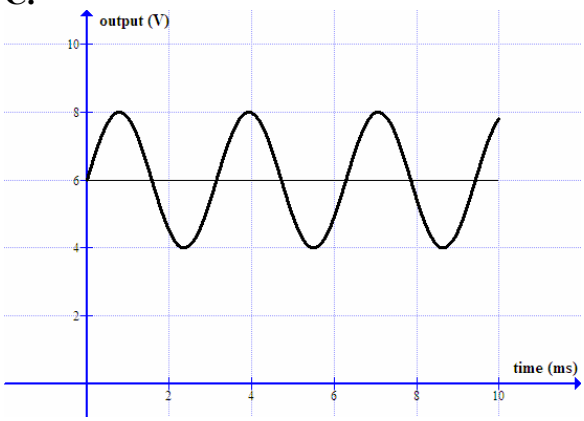
Figure 7b

Which of the following best describes the output?

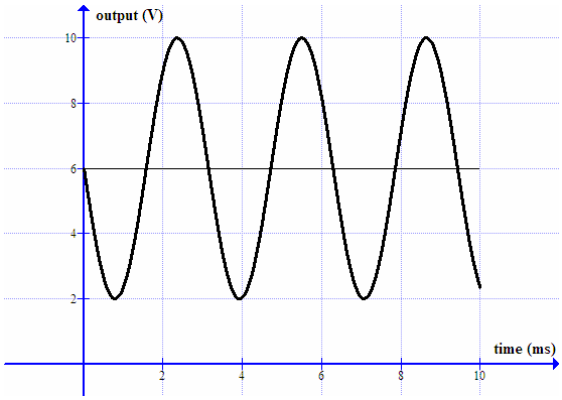
A.



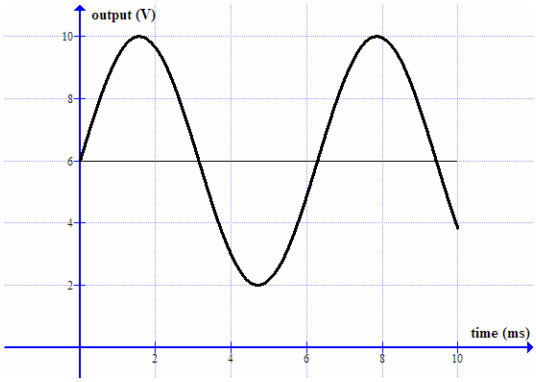
C.



B.



D.



Answer is B.

Worked solution

Frequency remains the same. Graph is inverted. Gain is 1000.

2 marks

Question 12

For the transistor shown in Figure 8, label the base (B), emitter (E) and collector (C).

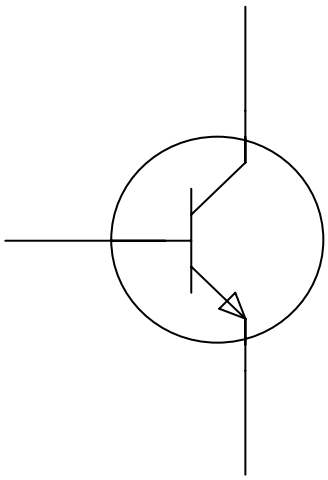
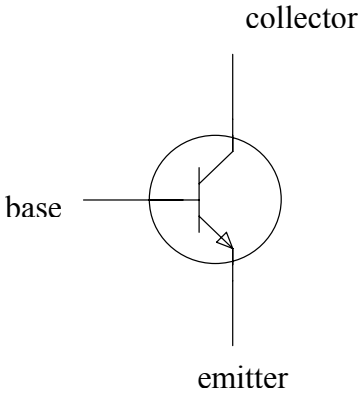


Figure 8

Worked solution



1 mark

Mark allocation

- 1 mark for labelling all diagram parts correctly. 0 marks if any mistakes.

Question 13

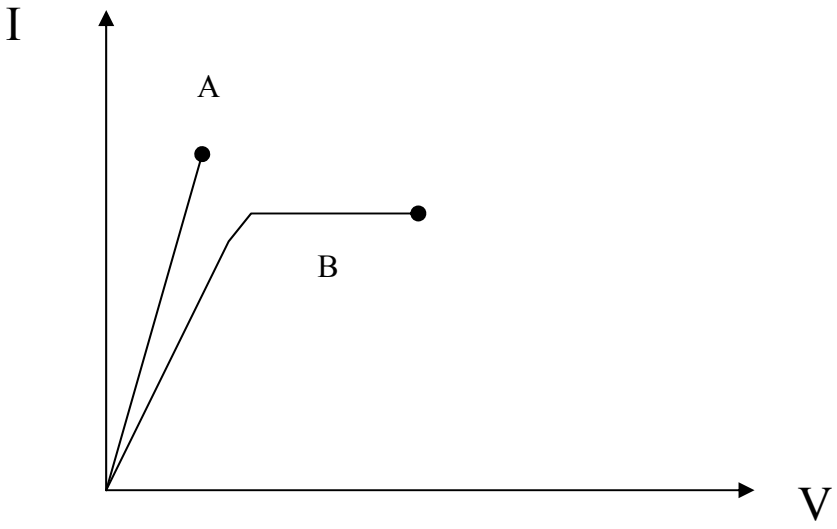


Figure 9

Which of the resistors in Figure 9 is 'ohmic'? Explain.

Worked solution

Resistor A is ohmic (1 mark) because it is always linear (1 mark); that is, it always obeys Ohm's law.

2 marks

END OF SECTION A

SECTION B – Detailed studies

Detailed study 1 – Einstein's special relativity

The following information applies to Questions 1–3.

Michelson and Morley set up a famous experiment, as shown in Figure 1.

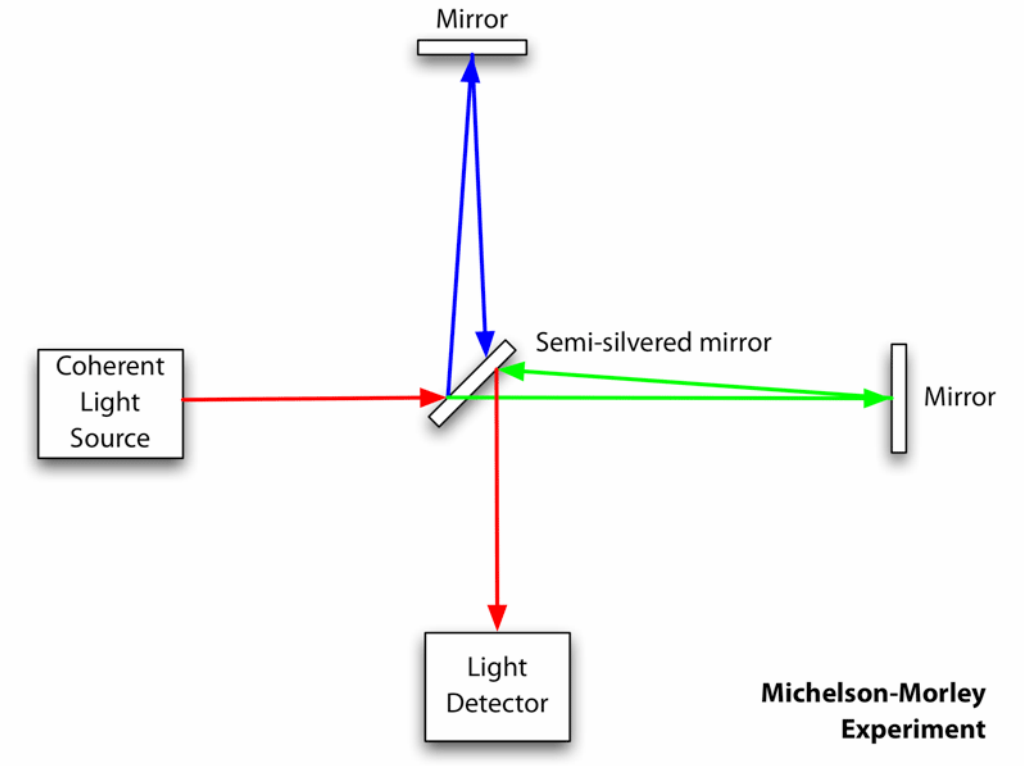


Figure 1

Question 1

What is the name of this piece of apparatus?

Worked solution and mark allocation

An Interferometer.

1 mark

Question 2

What is its purpose and how does it work?

Worked solution and mark allocation

Its purpose is to measure the speed of the Earth through the ether and/or detect the presence of the ether. (1 mark)

If there was an ether, the light would be reflected and be out of phase. (1 mark)

An interference pattern would then be observed. (1 mark)

3 marks

Question 3

What was the outcome of the experiment?

Worked solution and mark allocation

It was a null result. (1 mark)

They did not observe any interference pattern, thus did not detect any velocity/evidence of ether. (1 mark)

2 marks

The following information applies to Questions 4–8.

In the year 2200, a mission is sent to an 'Earth-like' planet to explore its possibilities of human habitation. A group of astronauts is sent at 80% the speed of light (0.8 c), as measured by astronomers on Earth. The planet is known to be 20 light years away.

Question 4

As soon as the astronauts arrive, they send a message back to Earth. In what year will Earth receive their message?

Worked solution and mark allocation

From Earth's reference, it takes 20/0.8 = 25 years to reach the planet. (1 mark)

It will also take 20 years for the signal to return. (1 mark)

Total time is 45 years; hence, it will be the year 2245. (1 mark)

Year 2245

3 marks

Question 5

What is the Lorenz factor for the astronauts?

Worked solution

$$\text{Lorenz factor} = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$= \frac{1}{\sqrt{1-\frac{(0.8\,c)^2}{c^2}}} \qquad \text{(1 mark)}$$

$$= \frac{1}{\sqrt{1-0.64}}$$

$$= 1.67 \qquad \text{(1 mark)}$$

1.67

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 6

From the astronauts' reference, how long will the trip take to reach the Earth-like planet?

Worked solution

$$t = \frac{t_0}{\gamma} = \frac{25}{1.67} = 15 \text{ years}$$

15 years

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 7

Before the rocket leaves Earth, its length is measured to be 250 metres. When the astronauts leave Earth at 0.8 c, compared to its actual length, the rocket will appear, to an observer on Earth:

A. longer than 250 m
B. 250 m
C. shorter than 250 m
D. depends which way observer is travelling

Worked solution

Length only has *contractions* due to relativity.

C

2 marks

Question 8

On the trip, the astronauts measure the ship. To them, its length appears:

A. longer than 250 m
B. 250 m
C. shorter than 250 m
D. depends which way astronauts are travelling

Worked solution

The ship is not moving according to the astronauts' frame of reference.

B

2 marks

The following information applies to Questions 9 and 10.

The rest mass of an electron is 9.11×10^{-31} kg. It is then accelerated to 1.9×10^{8} ms^{-1}.

Question 9

What is the resting energy of the electron?

Worked solution

$E = mc^2$

$= 9.1 \times 10^{-31} \times (3 \times 10^8)^2$ J

$= 8.19 \times 10^{-14}$ J

8.19×10^{-14} J

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 10

What is the relativistic mass of the electron travelling at 1.9×10^{8} ms^{-1}?

Worked solution

$$\text{Mass} = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$= \frac{9.11\times10^{-31}}{\sqrt{1-\frac{(1.9\times10^8)^2}{(3\times10^8)^2}}}$$

$$= 1.18\times10^{-30} \text{ kg}$$

1.18×10^{-30} kg

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 11

The sun loses 5×10^9 kg of mass every second. How much energy does it lose in one Earth hour?

Worked solution

In 1 second:

$E = mc^2$

$= 5 \times 10^9 \times (3 \times 10^8)^2$

$= 4.5 \times 10^{26}$ J

$4.5 \times 10^{26} \times 60 \times 60 = 1.62 \times 10^{30}$ J

1.62×10^{30} J

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 12

Explain the meaning of the term 'inertial frame of reference'.

Worked solution

Inertial frame of reference is a frame of reference that has a constant velocity; that is, it is not accelerating.

2 marks

END OF DETAILED STUDY 1
SECTION B – continued
TURN OVER

Detailed study 2 – Investigating materials and their use in structures

The following information applies to Questions 1–3.

A fishing line of length 2 m, with a cross-sectional area of 3×10^{-6} m^2, has a stress breaking limit of 2×10^8 Nm^{-2} with a strain rating of 0.05.

Question 1

How much force can the line hold?

Worked solution

$$\sigma = \frac{F}{A}$$

$F = \sigma \times A$

$= 2 \times 10^8 \times 3 \times 10^{-6}$

$= 600$ N

600 N

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 2

How much will it stretch?

Worked solution

$$\varepsilon = \frac{\Delta x}{x}$$

$\Delta x = \varepsilon \times x$

$= 0.05 \times 2$

$= 0.1$ m

0.1 m

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer

Question 3

What is the Young's modulus for the fishing line?

Worked solution

$$\text{Young's modulus} = \frac{\text{Stress}}{\text{Strain}}$$

$$= \frac{2 \times 10^{8}}{0.05}$$

$$= 4 \times 10^{9} \text{ Nm}^{-2}$$

4×10^{9} Nm^{-2}

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer

Question 4

What does the area under a stress–strain graph measure? What is its unit?

Worked solution and mark allocation

Area under a stress–strain graph measures toughness or strain energy per cubic metre (not just strain energy). (2 marks)

Units are Jm^{-3}. (1 mark)

3 marks

The following information applies to Questions 5–7.

A new concrete sign has been erected in Capital City. It is supported by a concrete column, as shown in Figure 1.

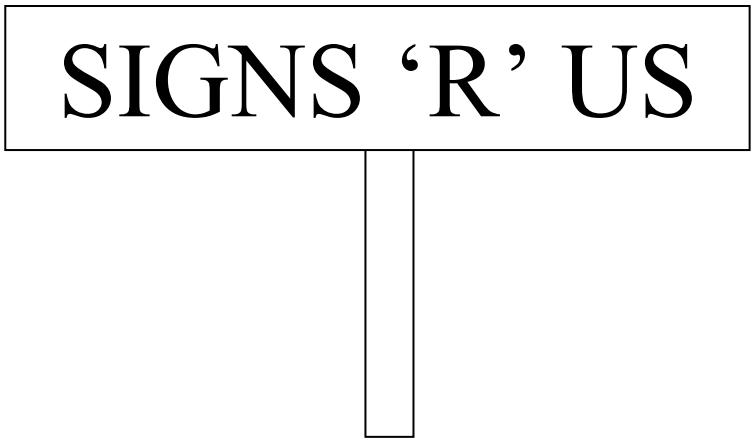
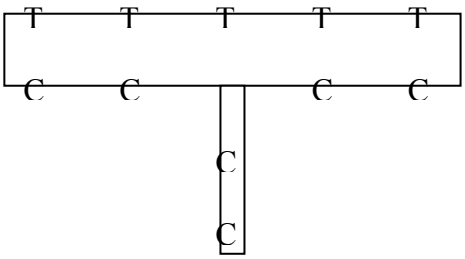


Figure 1

Question 5

Place C for compression and T for tension in appropriate spots on the sign and column.

Worked solution



Mark allocation

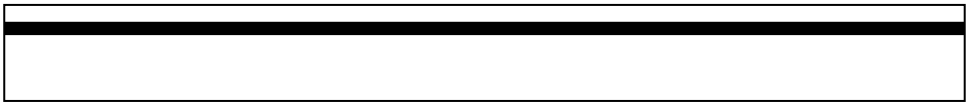
- 1 mark for correctly marking tension on top.
- 1 mark for correctly marking compression on the underside and in column.

2 marks

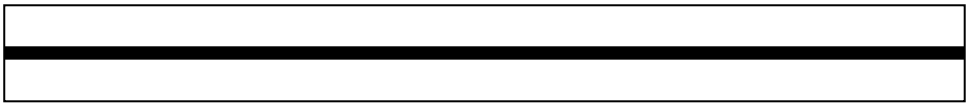
Question 6

Which of the following shows the best placement of reinforcing steel rods to provide maximum strength for the **sign**?

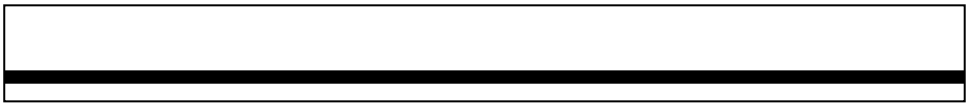
A.



B.



C.



D.

Solution

A

2 marks

Question 7

Explain your choice.

Worked solution and mark allocation

Concrete is weakest under tension. (1 mark)

Needs reinforcing where sign is under tension. (1 mark)

2 marks

The following information applies to Questions 8 and 9.

When Ash, who weighs 100 kg, gets into his car, his car sinks towards the ground by 10 cm. He has four identical shock absorbers.

Question 8

What is ***k***, the spring constant, for the spring in one shock absorber? You may assume that Ash's weight is distributed evenly amongst the four shock absorbers.

Worked solution and mark allocation

Force on each spring is one-quarter of Ash's weight = 0.25 × 100 × 10 = 250 N (1 mark)

Distance is 10 **cm**, which is 0.1 **m**.

$$k = \frac{\text{Force}}{\text{Distance}}$$
$$= \frac{250\ \text{N}}{0.1}$$
$$= 2500\ \text{Nm}^{-1} \qquad \text{(1 mark)}$$

$2500\ \text{Nm}^{-1}$

2 marks

Ash is now driving his car over a 20 m beam bridge, which is supported by two pillars. The bridge has a mass of 2000 kg, and Ash and his car have a combined mass of 800 kg. Ash stops 5 m from the end of the bridge to admire the view, as shown in Figure 2.

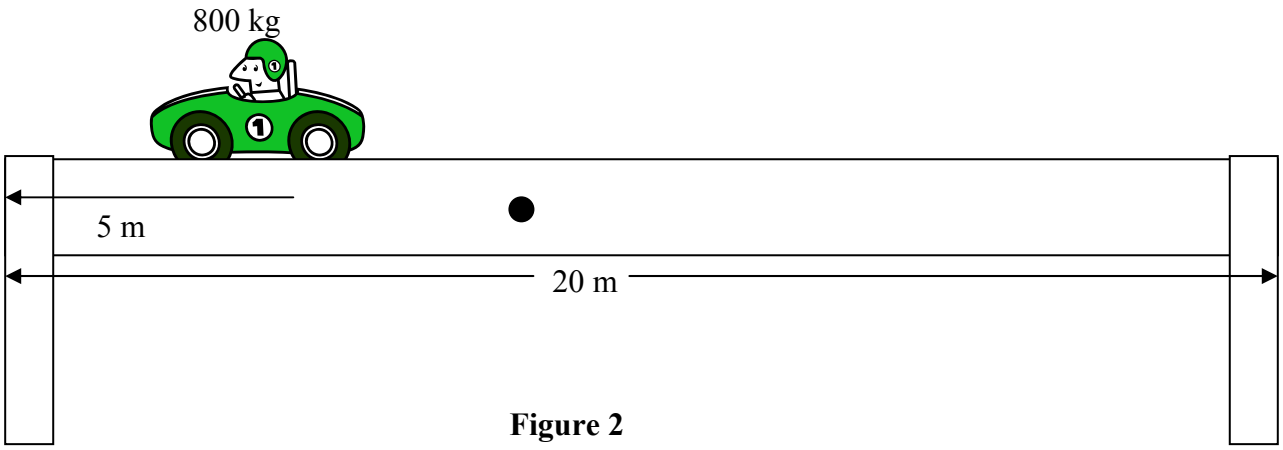


Figure 2

Question 9

What are the compression forces on the left pillar?

Worked solution and mark allocation

Forces due to bridge = Half of bridge weight = $0.5 \times 2000 \times 10 = 10\,000$ N (1 mark)

Forces due to Ash:

Take moments about RHS pillar

Torque (anti-clockwise) = $F \times r$
$= m \times g \times r$
$= 800 \times 10 \times 15$
$= 1.2 \times 10^5$ Nm (1 mark)

Torque (clockwise) = Torque (anti-clockwise)

$Fr = 1.2 \times 10^5$

$F \times 20 = 1.2 \times 10^5$

$F = 6000$ N (1 mark)

Total = 16 000 N

$= 1.6 \times 10^4$ N (1 mark)

1.6×10^4 N

4 marks

The following information applies to Questions 10 and 11.

Figure 3 is a stress–strain graph for two different materials.

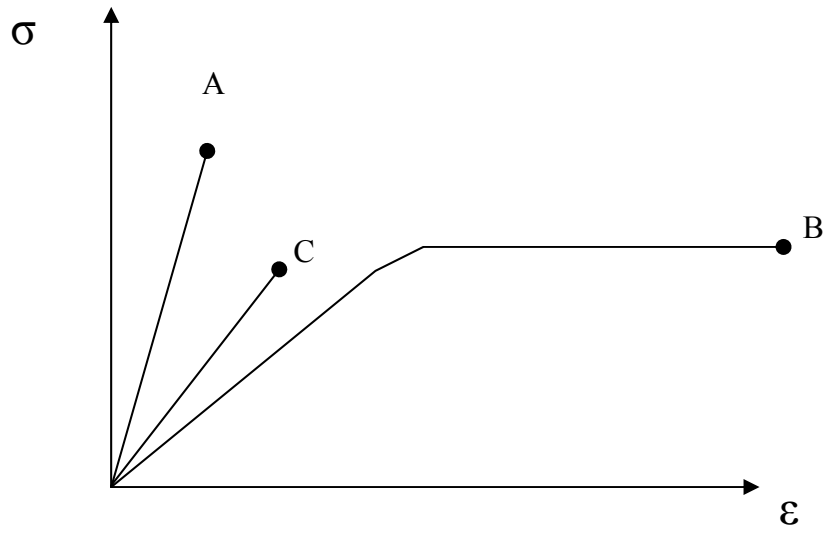


Figure 3

Question 10

Which of the materials is the most ductile? Explain.

Worked solution and mark allocation

Material B (1 mark) because it has the large plastic region (1 mark).

B

2 marks

Question 11

Which of the materials is the strongest? Explain.

Worked solution and mark allocation

Material A (1 mark) because it has the highest stress value (1 mark).

A

2 marks

END OF DETAILED STUDY 2
SECTION B – continued
TURN OVER

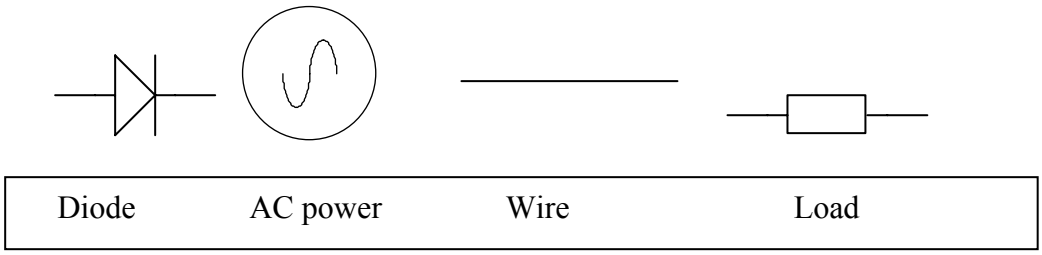
Detailed study 3 – Further electronics

The following information applies to Questions 1–5.

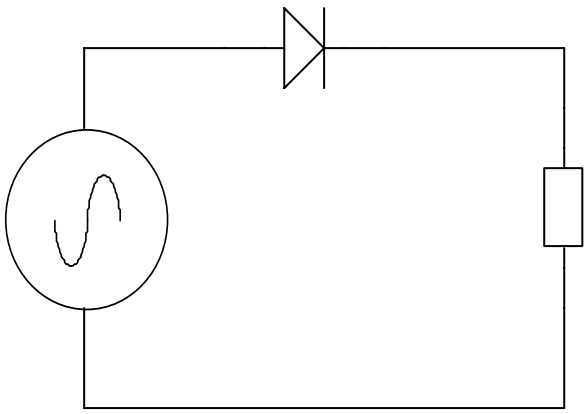
Bill and Bob are making some rectified power supplies. They have only an AC power supply, some diodes (6), wire (plenty) and a load/resistor they want to run off DC. The AC power supply is 12 V_{RMS}, 25Hz.

Question 1

Bill wants to make a half-wave bridge rectifier. Draw one in the space provided. Use the following symbols.



Worked solution



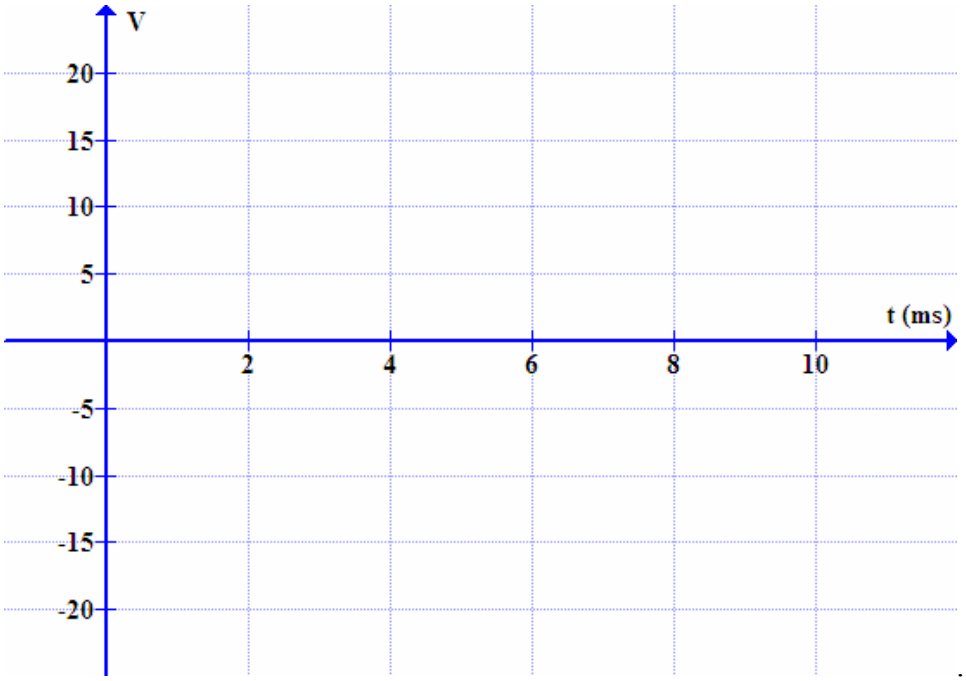
2 marks

Mark allocation

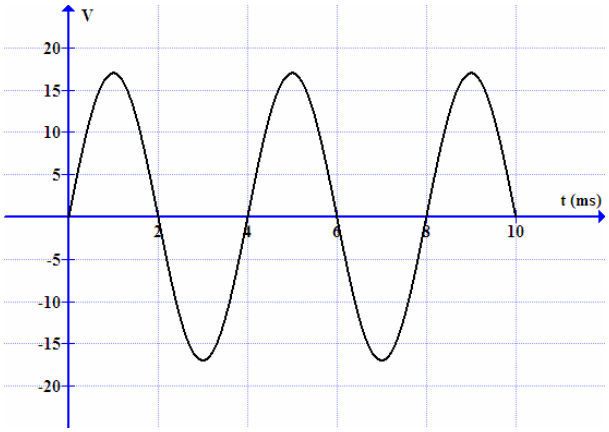
- 1 mark for showing diode and load are connected (diode drawn backwards is OK).
- 1 mark for drawing the circuit correctly.

Question 2

Sketch the display that Bill would see if he connected his Cathode Ray Oscilloscope (CRO) across the AC power supply.



Worked solution



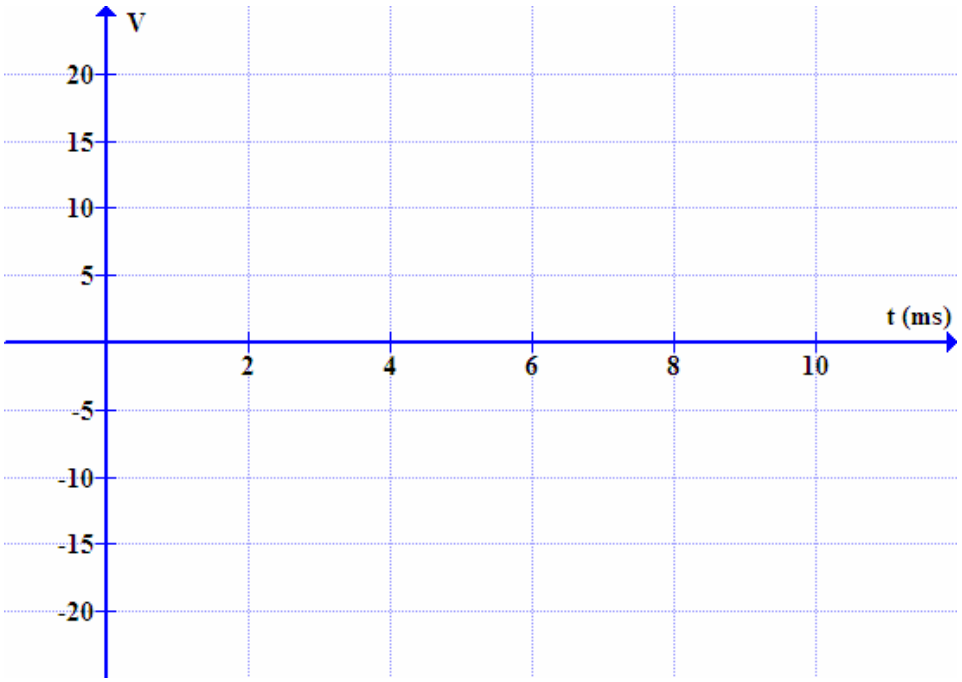
3 marks

Mark allocation

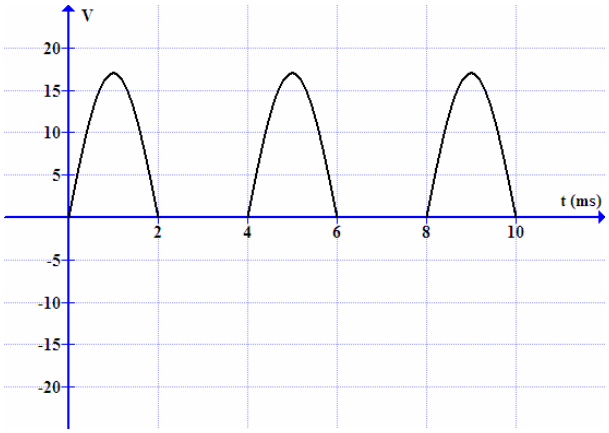
- 1 mark for showing general shape.
- 1 mark for calculating peak voltage is approximately 16.97 V.
- 1 mark for calculating frequency correctly.

Question 3

Bill now places his CRO across the load. Sketch the display on the CRO.



Worked solution



2 marks

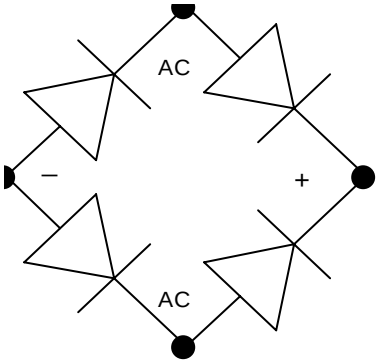
Mark allocation

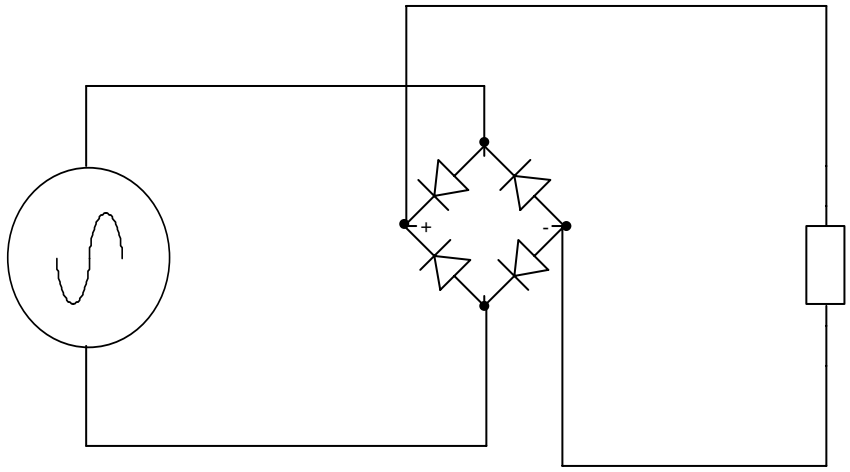
- Same as for previous answer (1 mark), except for correctly showing that there is no graph below *x*-axis (1 mark).

Question 4

Bob now wants to make a full-wave bridge rectifier. Draw one from the available supplies. Connect it to his load.

Worked solution





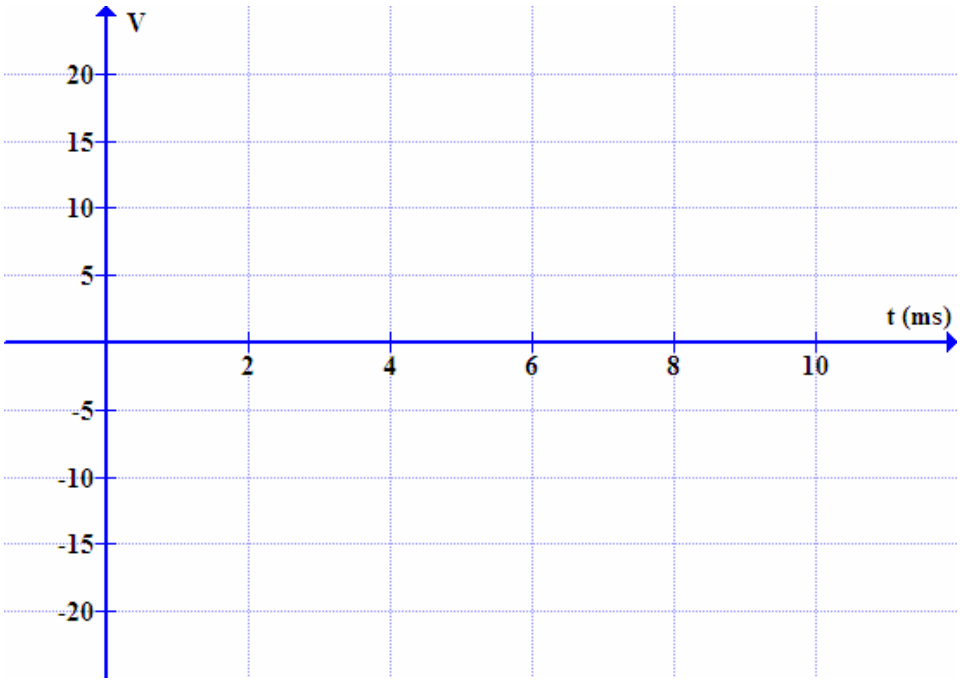
3 marks

Mark allocation

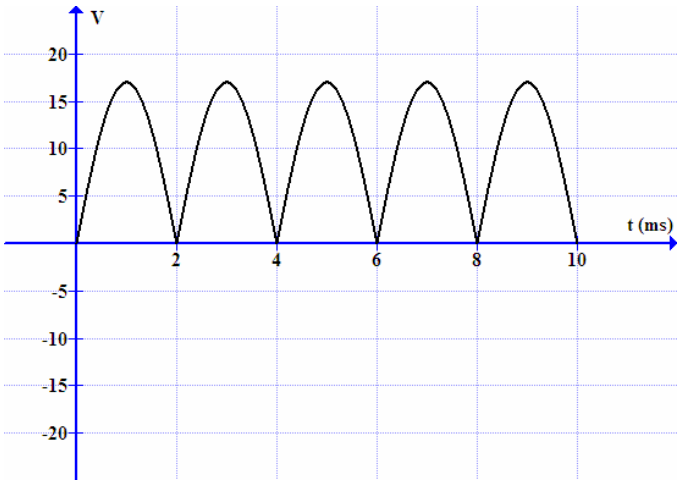
- 1 mark for drawing diodes in the right way.
- 1 mark for drawing AC and output connection correctly.
- 1 mark for drawing connected load correctly; that is, showing load connected to correct outputs.

Question 5

Bob connects a CRO across the load. Sketch the display.



Worked solution



2 marks

Mark allocation

- 1 mark for showing same period and amplitude as answer to Question 3.
- 1 mark for correctly drawing all waves above *x*-axis.

The following information applies to Questions 6 and 7.

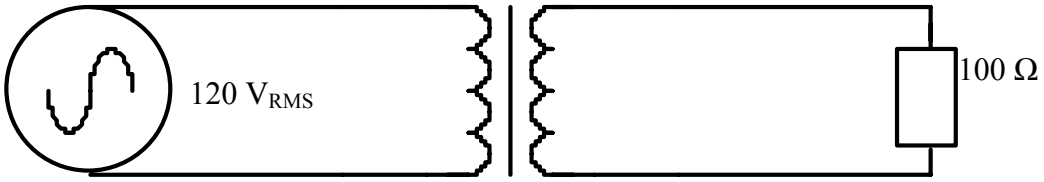


Figure 1

A transformer, as shown in Figure 1, is connected to a 120 V_{RMS} AC power supply. The output voltage required is 24 V_{RMS} and is connected to a load of 100 Ω. The number of coils in the secondary is 10.

Question 6

What number of coils is required in the primary?

Worked solution

$$\frac{n_p}{V_p} = \frac{n_s}{V_s}$$

$$\frac{n_p}{120} = \frac{10}{24}$$

$$n_p = 50$$

50 coils

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 7

How much power is dissipated through the 100 Ω resistor?

Worked solution

$$P = \frac{V^2}{R}$$

$$= \frac{24^2}{100}$$

$$= 5.76 \text{ W}$$

5.76 W

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

The following information applies to Questions 8 and 9.

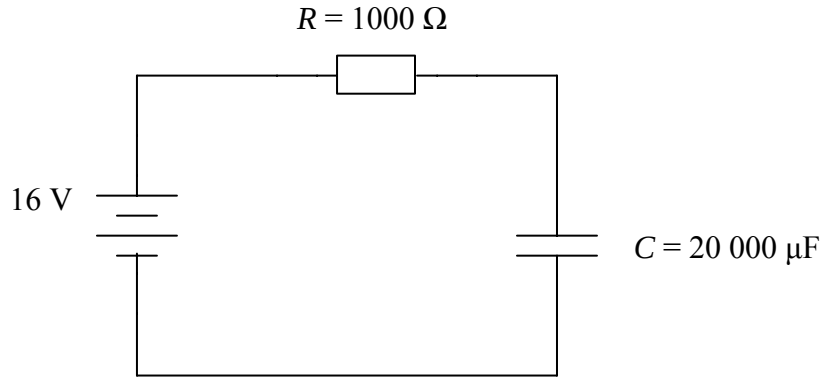


Figure 2

A capacitor and resistor are connected to a 16 V DC power supply, as shown in Figure 2.

Question 8

What is the time constant (τ) for this circuit?

Worked solution

$T = RC$

$= 1 \times 10^3 \times 20\,000 \times 10^{-6}$

$= 20$ s

20 s

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 9

How long until the potential difference across the capacitor is 10.7 V?

Worked solution and mark allocation

10.7 V is 67% of 16 V (1 mark)

67% is one time constant = 20s (1 mark)

20 s

2 marks

Question 10

Explain the purpose of a heat sink.

Worked solution and mark allocation

Removes heat (1 mark) from devices, whose performance **will** suffer (1 mark) if they overheat.

2 marks

The following information applies to Questions 11 and 12.

A CRO is connected to the output of a power supply. The CRO is set on CAL. The trace displays a peak to peak voltage of 34 V and a period of 25 ms.

Question 11

What is the RMS voltage?

Worked solution

$V_{p-p} = 68$ V

$$V_{RMS} = \frac{V_{p-p}}{2\sqrt{2}}$$

$$= \frac{34}{2\sqrt{2}}$$

$$= 12 \text{ V}$$

12 V

2 marks

Mark allocation

- 1 mark for substituting correct values into the correct formula.
- 1 mark for correct answer.

Question 12

What is the frequency of the AC supply?

Worked solution

$$f = \frac{1}{T}$$

$$= \frac{1}{20 \times 10^{-3}}$$

$$= 50 \text{ Hz}$$

50 Hz

1 mark

END OF WORKED SOLUTIONS