EPH N(A) LEVEL TOPICAL SCIENCE (PHYSICS) ANSWERS (2011–2020)

Must-Know Concepts INCLUDED Questions Analysis

TOPIC 1 Physical Quantities, Units and Measurement

Paper 1

1. **A**

Height of 5 blocks = 15 cm
Height of 1 block = 15 cm ÷ 5
= 3 cm

Must-Know Concept:
Height of 1 block = $\frac{\text{total height}}{\text{number of blocks}}$

2. **A**

Length of cotton = 15.6 cm – 2.4 cm
= 13.2 cm

Distance once round the pen = 13.2 cm ÷ 6
= 2.2 cm

Must-Know Concept:
Distance round pen = $\frac{\text{length of cotton}}{\text{number of turns}}$

3. **C**

Width of the cupboard = 83 cm + 50 cm
= 133 cm
= 1.33 m

Must-Know Concept:
Width of cupboard = Marking on metre rule aligned with 0 cm marking of half-metre rule + Length of half-metre rule

4. **B**

Time taken = 46.5 s – 0.5 s
= 46.0 s

Must-Know Concept:
Duration = End time – Start time

5. **D**

m is the symbol of prefix milli. M is the symbol of prefix mega. n is the symbol of prefix nano. μ is the symbol of prefix micro.

Must-Know Concept:
Recall the symbol of prefix micro.

6. **A**

Vector quantities are physical quantities that have both magnitude and direction.

Must-Know Concept:
Vector quantities have both magnitude and direction.

7. **D**

Scalars have magnitude only while vectors have both magnitude and direction.

Must-Know Concept:
Recall the difference between scalar and vector quantities.

8. **B**

A vector quantity has both magnitude and direction.

Must-Know Concept:
Recall the definition of vector quantity.

9. **A**

Inner diameter = 11 mm + 0.7 mm
= 11.7 mm
Outer diameter = 22 mm + 0.3 mm
= 22.3 mm
Thickness
= (Outer diameter – Inner diameter) ÷ 2
= (22.3 mm – 11.7 mm) ÷ 2
= 5.3 mm

Must-Know Concept:
Recall the use of vernier calipers.

10. **B**

μ prefix means 10^{-6}. Hence, 1 μs will mean 10^{-6} s or 0.000001 s.

Must-Know Concept:
Recall the prefixes symbols and meaning.

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Paper 2

Section A

1.

unit	symbol	multiple
gram	g	1
kilogram	**kg**	1000
microgram	μg	1×10^{-6}
milligram	mg	**1×10^{-3}**

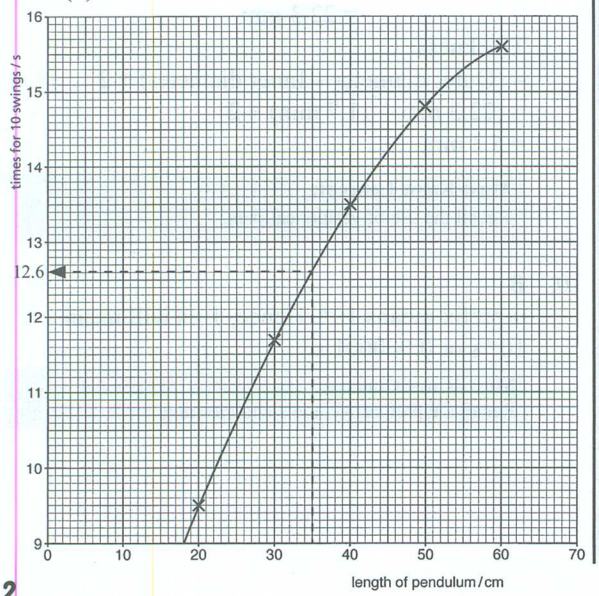
2.

quantity to be measured	name of instrument for measuring the quantity	unit in which the quantity is measured
the diameter of a thin wire	**micrometer screw gauge**	**millimetre (mm)**
the current through a lamp	**ammeter**	**ampere (A)**
the weight of a brick	**electronic balance**	**kilogram (kg)**

3. (a)

Length of pendulum / cm	**Time for 10 full swings / s**
20	9.50
30	11.70
40	13.50
50	14.80
60	15.60

(b)



(c) 12.60 s

4.

This needs to be measured, together with distance moved, to calculate work done.	acceleration force time velocity
This is the symbol for the prefix micro.	μ m M n
This instrument is used to measure potential difference.	ammeter newton meter thermometer voltmeter

5. (a) Micrometer screw gauge

(b) Balance

(c) Stopwatch

6. (a) 15.6 mm or 1.56 cm

Explanation:

Reading on the main scale = 1.5 cm

Reading on the vernier scale = 0.06 cm

Length of block = 1.5 + 0.06 = 1.56 cm

(b) 47 cm^3

7.

unit	quantity
coulomb	**charge**
metres per second	**speed**
ohm	**resistance**
volt	**e.m.f.**

TOPIC 2 Kinematics

Paper 1

1. **A**

Time taken by the man to cross the road

= 8.0 m ÷ 2.0 m/s

= 4.0 s

Must-Know Concept:

Time taken = $\frac{\text{distance}}{\text{speed}}$

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2. **B**

The area under the line QR of the speed-time graph is used to find the distance travelled after he applies the brakes.

Must-Know Concept:
Distance = Area under speed-time graph

3. **C**

Area under the speed-time graph

$= \frac{1}{2} \times 10 \text{ m/s} \times 5 \text{ s}$

$= 25 \text{ m}$

Must-Know Concept:
Distance = Area under speed-time graph

4. **A**

Since the object is falling in a vacuum, there is no air resistance. Only gravitational force acts on it. According to $F = ma$, its acceleration is constant.

Must-Know Concept:
There is no air resistance in a vacuum.

5. **A**

Time spent, $t = \frac{\text{Distance}}{\text{Average speed}}$

$= \frac{100 \text{ m}}{25 \text{ m/s}}$

$= 4 \text{ s}$

Acceleration, $a = \frac{v - u}{t}$

$= \frac{30 \text{ m/s} - 20 \text{ m/s}}{4 \text{ s}}$

$= 2.5 \text{ m/s}^2$

Must-Know Concept:
Accecleration = $\frac{\text{change in velocity}}{\text{time taken}}$

6. **A**

The acceleration of a free-falling object near to the Earth's surface is approximately 10 m/s^2.

Must-Know Concept:
The acceleration due to gravity above the surface of the Earth is constant.

7. **D**

An object near to the surface of the Earth undergoes a constant acceleration of 10 m/s^2.

Must-Know Concept:
Acceleration is the rate of change of velocity.

8. **C**

Area under the graph

= Area of triangle + area of rectangle

$= \frac{1}{2}(20)(20) + (30)(20)$

$= 800 \text{ m}$

OR

= Area of trapezium

$= \frac{1}{2}(30 + 50)(20)$

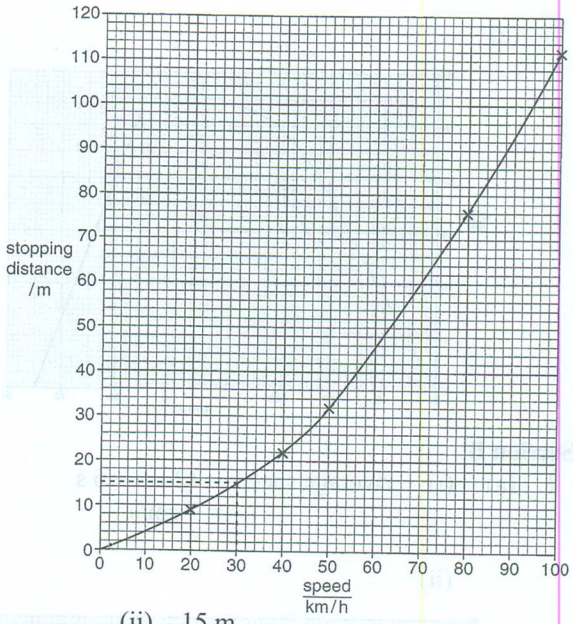
$= 800 \text{ m}$

Must-Know Concept:
Area under the graph represents distance travelled by the object.

Paper 2

Section A

1. (a) (i)



(ii) 15 m

(b) Increase

When the road is wet, the frictional force acting on the tyres decreases. Hence, the stopping distances for the car would increase.

2. Average speed = total distance travelled ÷ total time taken

$= 6 \text{ m} \div 1.5 \text{ s}$

$= 4 \text{ m/s}$

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3. (a) conclusion: The speed of the trolley is increasing.
explanation: The distance between two consecutive dots is increasing.

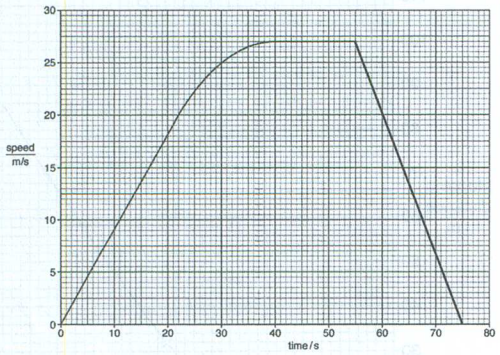
(b) (i) 3.0 cm

(ii) Average speed $= \frac{3.0 \text{ cm}}{0.02 \text{ s}}$
$= 150 \text{ cm/s}$

4. (a) The train experiences a uniform acceleration as the gradient of the speed-time graph is constant for the first 20 s.

(b) 39 s

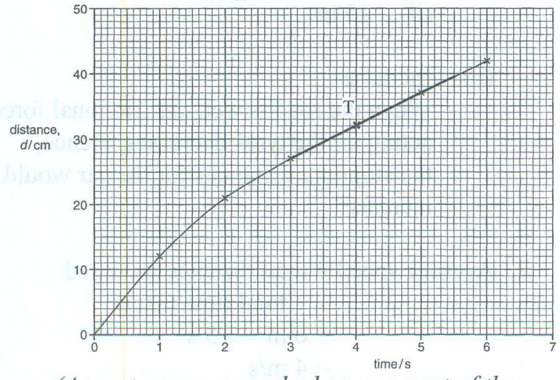
(c)



Section B

1. (a) (i) Average speed $= 42 \text{ cm} \div 6 \text{ s}$
$= 7 \text{ cm/s}$

(ii)



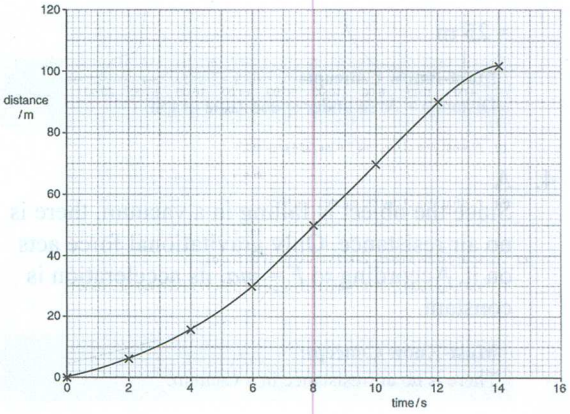
(Accept answers marked on any part of the bold line.)

(iii) 47 cm

(b) (i) The time taken decreases.

(ii) Thin oil has a lower density than thick oil. Thus, the upward resistant force on the ball bearing will be smaller in thin oil than in thick oil, causing the ball bearing to reach the bottom of the measuring cylinder faster.

2. (a)(b)



(c) From the curved line drawn in (a), the distance is 22 m.

(d) Total time taken between 50 m and 90 m
$= 12 \text{ s} - 8 \text{ s}$
$= 4 \text{ s}$
Average speed
$= \frac{\text{Total distance travelled}}{\text{Total time taken}}$
$= \frac{90 \text{ m} - 50 \text{ m}}{4 \text{s}}$
$= 10 \text{ m/s}$

3. Average speed, $v = \frac{s}{t}$
$= \frac{1050 \times 1000 \text{ m}}{150 \times 3600 \text{ s}}$
$= 1.9 \text{ m/s}$ (2 sig. fig.)

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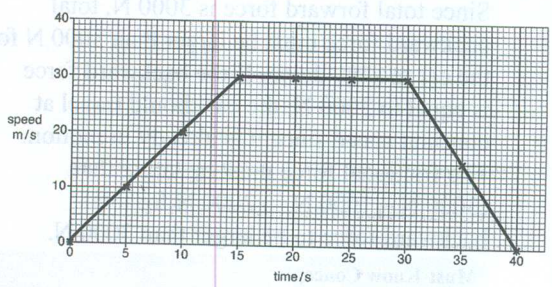
4. (a)



(b) Acceleration $= \frac{(30 - 0)\ \text{m/s}}{(15 - 0)\ \text{s}}$
$= 2.0\ \text{m/s}^2$

Explanation:
Make sure you know how to perform calculations using
Acceleration $= \frac{\text{final speed} - \text{initial speed}}{\text{time taken}}$

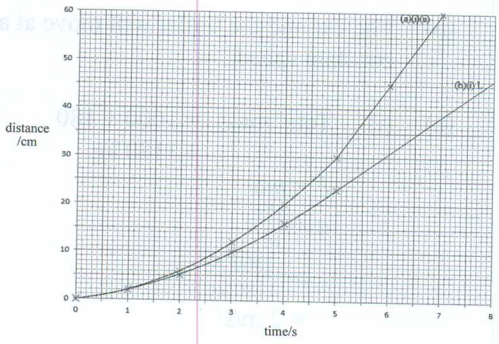
(c) Total distance travelled
$= \frac{1}{2} \times (15\ \text{s} + 40\ \text{s})\ (30\ \text{m/s})$
$= 825\ \text{m}$

Explanation:
Distance travelled = area under the speed-time graph

5. Average speed
$= \frac{350\ \text{km}}{1.25\ \text{h}}$
$= 280\ \text{km/h}$

Explanation:
Average speed $= \frac{\text{total distance}}{\text{total time}}$

6. (a)(i)(ii), (b)(i)



(iii) 5.0 s

(b) (ii) When thicker oil is used in the experiment, the metal ball experiences higher resistance and hence, it falls through the column slower. The ball reaches the terminal velocity of a lower value earlier than in the normal oil.

(c) (i) Vernier calipers/Micrometer screw gauge

(ii) The larger metal ball has a larger surface area and size, so it experiences more resistance, and hence it takes more time to fall a certain distance through the oil.

TOPIC 3 Dynamics

Paper 1

1. **B**
For an object to be in equilibrium, there must be no resultant force.

Must-Know Concept:
The resultant force is zero when the object is in equilibrium.

2. **C**
Friction opposes the movement of the cheetah in the air. However, friction between the cheetah's feet and the ground enables the cheetah to move forward. Thus, when the friction with air is low and friction with ground is high, the cheetah will reach its greatest maximum speed.

Must-Know Concept:
Friction with air is a negative effect while friction with ground is a positive effect.

3. **B**
Since the wooden plank is in equilibrium, the total upward force is equal to the total downward force.

Must-Know Concept:
The resultant force is zero when the object is in equilibrium.

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4. **A**
Resultant force = 15 N + 10 N – 20 N
= 5 N (to the left)

Must-Know Concept:
The resultant force is equivalent to the individual forces combined in terms of magnitude and direction.

5. **A**
To make the brakes work efficiently, more friction is required. This can be realised by drying the wheel rim.

Must-Know Concept:
Friction is important for the brake to work efficiently.

6. **C**
For the object to be in equilibrium, the forces applied on it must be balanced. In the situation of option C, the two forces acting in the same direction cannot be balanced. Thus, the object cannot be in equilibrium.

Must-Know Concept:
The two forces need to be balanced for the object to be in equilibrium.

7. **B**
Friction is the contact force that opposes or tends to oppose motion between surfaces in contact.

Must-Know Concept:
Recall the major forces and their directions.

8. **B**
$m = \frac{F_1}{a_1}$
$= \frac{10\text{ N}}{5\text{ m/s}^2}$
$= 2\text{ kg}$
$F_2 = ma_2$
$= 2\text{ kg} \times 1\text{ m/s}^2$
$= 2\text{ N}$

Must-Know Concept:
The mass of the object is constant.

9. **D**
Since total forward force is 3000 N, total backward force must be larger than 3000 N for the car to slow down. If the backward force is equal to 3000 N, the car should travel at constant speed since it is already in motion. The frictional force must be larger than (3000 N – 1000 N =) 2000 N for total backward force to be larger than 3000 N.

Must-Know Concept:
When forces are balanced, object will travel at constant velocity or remain at rest. Only when forces are not balanced, then object will change in velocity (which is this case).

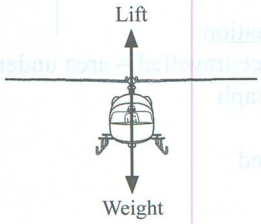
10. **B**
To change the motion of an object, a force needs to be applied due to its inertia.
Resultant force = Mass × Acceleration

Must-Know Concept:
Inertia means that an object at rest tends to be at rest or an object in motion tends to be in motion.

Paper 2

Section A

1. (a)



(b) The size of the weight is equal to the size of the lift.

Section B

1. (a) Frictional force

(b) The car and the trailer will move at a constant speed.

(c) (i) Total mass = 1000 + 180
= 1180 kg

$F = ma$
$a = \frac{F}{m}$
$= \frac{2360\text{ N}}{1180\text{ kg}}$
$= 2\text{ m/s}^2$

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(ii) $a = \frac{v-u}{t}$

$v = at + u$

$= 2\ \text{m/s}^2 \times 6\ \text{s} + 0$

$= 12\ \text{m/s}$

TOPIC 4 Mass, Weight and Density

Paper 1

1. **D**

Mass is a measure of the amount of substance in a body, measured in kilograms. Weight is a force and is measured in newtons.

Must-Know Concept:
Weight is a force but mass is not.

2. **B**

$\text{Density} = \frac{\text{mass}}{\text{volume}}$

Let the mass of each solid be x g.

Option A: Volume $= 2\ \text{cm} \times 2\ \text{cm} \times 1\ \text{cm}$

$= 4\ \text{cm}^3$

$\therefore \text{Density} = \frac{x}{4}\ \text{g/cm}^3$

Option B: Volume $= 1\ \text{cm} \times 1\ \text{cm} \times 1\ \text{cm}$

$= 1\ \text{cm}^3$

$\therefore \text{Density} = \frac{x}{1}$

$= x\ \text{g/cm}^3$

Option C: Volume $= 1\ \text{cm} \times 1\ \text{cm} \times 2\ \text{cm}$

$= 2\ \text{cm}^3$

$\therefore \text{Density} = \frac{x}{2}\ \text{g/cm}^3$

Option D: Volume $= 2\ \text{cm} \times 2\ \text{cm} \times 2\ \text{cm}$

$= 8\ \text{cm}^3$

$\therefore \text{Density} = \frac{x}{8}\ \text{g/cm}^3$

Must-Know Concept:
$\rho = \frac{m}{V}$

3. **A**

Option A: $\text{Density} = \frac{10\ \text{g}}{1\ \text{cm}^3}$

$= 10\ \text{g/cm}^3$

Option B: $\text{Density} = \frac{60\ \text{g}}{8\ \text{cm}^3}$

$= 7.5\ \text{g/cm}^3$

Option C: $\text{Density} = \frac{210\ \text{g}}{27\ \text{cm}^3}$

$= 7.8\ \text{g/cm}^3$ (2 sig. fig.)

Option D: $\text{Density} = \frac{500\ \text{g}}{64\ \text{cm}^3}$

$= 7.8\ \text{g/cm}^3$ (2 sig. fig.)

Must-Know Concept:
$\rho = \frac{m}{V}$

4. **C**

Weight is a force. Mass is the amount of substance in an object.

Must-Know Concept:
Weight is a force but mass is not.

5. **B**

Mass is a measure of the amount of substance in a body and is not dependent on its size. Weight is the amount of gravitational force acting on a body. Weight is the product of mass and gravitational field strength. Thus, in the same gravitational field (the Earth), heavier objects always have more mass than light ones. There are many types of balances. Some balances, such as the spring balance, measure weight. Some balances, such as the beam balance, measure mass.

Must-Know Concept:
Recall the definition and measurement of mass and weight.

6. **D**

Volume of liquid $= 20\ \text{cm}^3$

$\text{Density of liquid} = \frac{\text{mass}}{\text{volume}}$

$= \frac{16\ \text{g}}{20\ \text{cm}^3}$

$= 0.80\ \text{g/cm}^3$

Must-Know Concept:
$\rho = \frac{m}{V}$

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7. **D**

Gravitational field strength
$= \frac{\text{gravitational force}}{\text{mass}}$
$= \frac{18\text{ N}}{2.0\text{ kg}}$
$= 9.0\text{ N/kg}$

Option A: Gravitational field strength
$= \frac{100\text{ N}}{10\text{ kg}}$
$= 10\text{ N/kg}$ (✗)

Option B: Gravitational field strength
$= \frac{250\text{ N}}{10\text{ kg}}$
$= 25\text{ N/kg}$ (✗)

Option C: Gravitational field strength
$= \frac{40\text{ N}}{10\text{ kg}}$
$= 4.0\text{ N/kg}$ (✗)

Option D: Gravitational field strength
$= \frac{90\text{ N}}{10\text{ kg}}$
$= 9.0\text{ N/kg}$ (✓)

Must-Know Concept:
$g = \frac{W}{m}$

8. **A**

Option A: The density of mercury is the greatest in the table, thus 1 cm^3 of mercury has the greatest mass. (✓)

Option B: The density of water is greater than that of kerosene, thus 1 cm^3 of water has a greater mass than 1 cm^3 of kerosene. (✗)

Option C: The density of iron is smaller than that of copper, thus 1 g of iron has a greater volume than 1 g of copper. (✗)

Option D: 1 g of mercury has the same mass as 1 g of copper. (✗)

Must-Know Concept:
$\rho = \frac{m}{V}$

9. **B**

Gravitational field strength, $g = \frac{W}{m}$

Option A: $g = \frac{15\text{ N}}{3.0\text{ kg}} = 5.0\text{ N kg}^{-1}$

Option B: $g = \frac{40\text{ N}}{4.0\text{ kg}} = 10\text{ N kg}^{-1}$ (greatest)

Option C: $g = \frac{30\text{ N}}{5.0\text{ kg}} = 6.0\text{ N kg}^{-1}$

Option D: $g = \frac{48\text{ N}}{6.0\text{ kg}} = 8.0\text{ N kg}^{-1}$

Must-Know Concept:
$g = \frac{W}{m}$

10. **A**

Weight, $W = mg$
$= 500\text{ kg} \times 0.014\text{ N/kg}$
$= 7.0\text{ N}$

Must-Know Concept:
$W = mg$

11. **B**

The property of a body that resists a change in its state of rest or motion is called inertia. It is due to the mass of the body.

Must-Know Concept:
Inertia is related to mass.

12. **B**

The inertia of an object refers to the reluctance of the object to change its state of rest or motion.

Must-Know Concept:
Recall the definition of inertia.

13. **D**

Weight = Mass × Gravitational Acceleration
$W = mg$
$W = 15\,000\text{ kg} \times 1.5\text{ N/kg}$
$= 22\,500\text{ N}$

Must-Know Concept:
$W = mg$

Paper 2

Section A

1. Volume of 6 aluminium balls
$= 110\text{ cm}^3 - 50\text{ cm}^3$
$= 60\text{ cm}^3$

Volume of 1 aluminium ball $= \frac{60\text{ cm}^3}{6}$
$= 10\text{ cm}^3$

Density, $\rho = \frac{m}{V}$
$= \frac{27\text{ g}}{10\text{ cm}^3}$
$= 2.7\text{ g/cm}^3$

2. Mass of block Y
$= \frac{0.5\text{ N}}{10\text{ N/kg}}$
$= 0.05\text{ kg}$
$= 50\text{ g}$

Density, $\rho = \frac{m}{V}$
$= \frac{50\text{ g}}{2\text{ cm} \times 5\text{ cm} \times 2\text{ cm}}$
$= 2.5\text{ g/cm}^3$

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Explanation:
Make sure you can perform calculations using Weight = mass × gravitational field strength and Density = $\frac{\text{mass}}{\text{volume}}$.

Section B

1. Inertia, which is the resistance of an object to the change in its state of motion, causes the soil to move forward instead of stopping with the trailer.

2. (a) Direction O

   (b) Due to its inertia, the racing car 'tries to resist' the change in motion, so it continues moving in the original direction O.

TOPIC 5 Turning Effect of Forces

Paper 1

1. **C**
   The pyramid has the widest base area, hence it is the most stable.

   Must-Know Concept:
   When the height is the same, the factor that affects stability is the width of base area.

2. **C**
   By the Principle of Moments,
   sum of all anticlockwise moments
   = sum of all clockwise moments

   Must-Know Concept:
   When an object is in rotational equilibrium, there is no resultant moment.

3. **D**
   Options A, B and C do not demonstrate the use of the moment of a force.

   Must-Know Concept:
   Recall the definition of the moment of a force.

4. **D**
   Only the force acting on the beam in the position in option D could balance the original force of 10 N. When this force acts in position D, both the resultant force and the resultant moment are zero, and hence the beam is in equilibrium.

   Must-Know Concept:
   Sum of anticlockwise moments = sum of clockwise moments

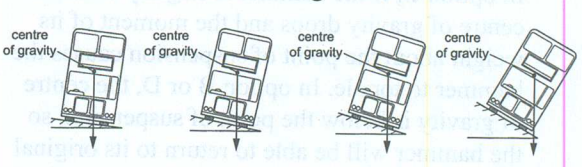
5. **A**
   Since the two masses are suspended at equal distances from the pivot, if X has a mass of more than 2 kg, there will be a resultant moment in the anticlockwise direction and it will fall. If X has a mass of exactly 2 kg, there will be no resultant moment and it will remain stationary. If X has a mass of less than 2 kg, there will be a resultant moment in the clockwise direction and it will rise.

   Must-Know Concept:
   The movement of the masses depends on the resultant moment.

6. **C**
   Since the bottle is just able to rest on the sloping surface without falling over, there is no resultant moment about the pivot point, which is at the lower edge of the bottom of the bottle. Hence, the line of action of its centre of gravity must pass through the pivot point.

   Must-Know Concept:
   The turning effect of the centre of gravity must pass through the pivot point so that there is no resultant moment.

7. **A**
   Only in the fourth diagram, the line of action through the centre of gravity of the model lies outside its base, causing it to fall over.



   Must-Know Concept:
   There must be a clockwise moment for the model of bus to fall over.

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8. **D**

By the Principle of Moments,
sum of all anticlockwise moments
= sum of all clockwise moments
$6\text{ N} \times 4\text{ m} = F \times 3\text{ m}$

$$F = \frac{6\text{ N} \times 4\text{ m}}{3\text{ m}}$$
$$= 8\text{ N}$$

Must-Know Concept:
Sum of anticlockwise moments = sum of clockwise moments

9. **C**

Using the Principle of Moments, to balance the beam, the sum of all anticlockwise moments must be equal to the sum of all clockwise moments.
Option A: $5\text{ N} \times 30\text{ cm} \neq 2\text{ N} \times 30\text{ cm}$ (✗)
Option B: $5\text{ N} \times 20\text{ cm} \neq 2\text{ N} \times 20\text{ cm}$ (✗)
Option C: $5\text{ N} \times 30\text{ cm} = 7.5\text{ N} \times 20\text{ cm}$ (✓)
Option D: $3\text{ N} \times 30\text{ cm} \neq 2\text{ N} \times 20\text{ cm}$ (✗)

Must-Know Concept:
Sum of anticlockwise moments = sum of clockwise moments

10. **B**

Referring to the diagram,
mass of block X = mass of block Y,
volume of block X ≠ volume of block Y.
Since density $= \frac{\text{mass}}{\text{volume}}$,
density of block X ≠ density of block Y.
Since weight = mass × gravitational field strength,
weight of block X = weight of block Y.

Must-Know Concept:
$\rho = \frac{m}{V}$

11. **C**

In option C, if the hammer is slightly tilted, its centre of gravity drops and the moment of its weight about the point of suspension causes the hammer to topple. In option B or D, the centre of gravity is below the point of suspension, so the hammer will be able to return to its original position much easier than the hammer in option C even when it is tilted.

Must-Know Concept:
The relative position of the centre of gravity to the point of suspension determines the stability.

12. **B**

By the Principle of Moments,
sum of all clockwise moments
= sum of all anticlockwise moments
$40.0\text{ N} \times 1.50\text{ m} = W \times 4.00\text{ m}$

$$W = \frac{40\text{ N} \times 1.50\text{ m}}{4.00\text{ m}}$$
$$= 15.0\text{ N}$$

Must-Know Concept:
Sum of anticlockwise moments = sum of clockwise moments

13. **C**

By the Principle of Moments,
sum of all anticlockwise moments
= sum of all clockwise moments
$100\text{ N} \times 0.50\text{ m} = F \times 0.50\text{ m} + 20\text{ N} \times 1.50\text{ m}$

$$F = \frac{100\text{ N} \times 0.50\text{ m} - 20\text{ N} \times 1.50\text{ m}}{0.50\text{ m}}$$
$$= 40\text{ N}$$

Must-Know Concept:
Sum of anticlockwise moments = sum of clockwise moments

14. **B**

To increase the stability of an object, its centre of gravity should be kept as low as possible while its base area should be kept as wide as possible.

Must-Know Concept:
The position of the centre of gravity and the width of the base area are the two factors that affect the stability of an object.

15. **D**

Uniform bar pivoted at its centre means that the weight of the bar will not contribute to any turning effect.
Sum of clockwise moments = Sum of anticlockwise moments
$F \times 3.0\text{ m} = 6.0\text{ N}\ (4.0\text{ m})$
$F = 8.0\text{ N}$

Must-Know Concept:
Sum of clockwise moments = Sum of anticlockwise moments (Applying Principle of Moments)

16. **D**

Only option D has the forces acting such that the forces result in anticlockwise moments only.

Must-Know Concept:
Moments of force = Force × Distance from pivot

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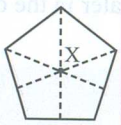
Paper 2

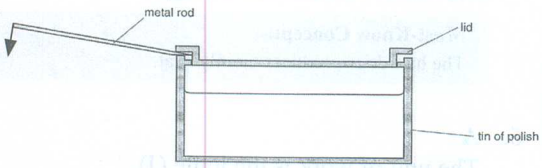
Section A

1. (a)



(b) When the centre of gravity is kept as low as possible, the stability of the car increases. Thus, it becomes safer for the driver to drive the car.

2.



Explanation:
The force is drawn at the position when the distance between the line of action of force to the pivot is the maximum.

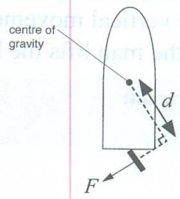
Section B

1. X
Reason 1: Vase X has a wider base.
Reason 2: Vase X has a lower centre of gravity.

2. (a) upthrust and weight

(b) (i) The yacht will turn clockwise about its centre of gravity.

(ii) The direction of the force exerted by water on the rudder is perpendicular to the line from the centre of gravity. Thus, it will produce a turning effect on the yacht and cause it to turn clockwise.
Explanation:



Moment of force = $F \times d$

TOPIC 6 Pressure

Paper 1

1. **D**
To sink less into soft ground, the wheel must exert less pressure on the ground. In this case, the pressure depends only on the contact area as the two carts have the same weight. Since the wide wheel has a larger contact area than the narrow wheel, it exerts less pressure on the ground and thus it sinks less.

Must-Know Concept:
$p = \frac{F}{A}$
For the carts of the same weight, the greater the contact area with the ground, the lesser the pressure it exerts.

2. **D**
By Newton's First Law of Motion, when the pin is at rest, the forces exerted by the thumb and by the finger on the pin are balanced. By Newton's Third Law, the pin exerts the same force on the thumb and the finger. However, as the area of the pin is smaller than that of the pinhead, by $p = \frac{F}{A}$, the pressure of the pin is larger on the thumb than on the finger.

Must-Know Concept:
Pressure depends on area when force is the same.

Paper 2

Section A

1. Pressure equals to force per unit area. Since the shoes worn by girl B have a smaller area in contact with the sand and the girls are of the same weight, the pressure exerted by girl B will be greater and leave deeper marks in the sand.

2. Pressure by block X, $p = \frac{F}{A}$
$= \frac{0.5\text{ N}}{2\text{ cm} \times 2\text{ cm}}$
$= 0.125\text{ N/cm}^2$

Explanation:
Make sure you can perform calculations using
Pressure = $\frac{\text{force}}{\text{area}}$.

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3. A tractor's weight exerts a large force on the ground. When the tyres are wide, the large force is distributed over a larger area, enabling the pressure to be smaller as pressure = Force ÷ Area.
When the pressure is smaller, the tractor is less likely to sink into the soft and sandy ground.

Section B

1. Weight of trailer and soil = 180 × 10
= 1800 N

$$p = \frac{F}{A}$$
$$= \frac{1800\ \text{N}}{2 \times 150\ \text{cm}^2}$$
$$= 6\ \text{N/cm}^2$$

TOPIC 7 Energy, Work and Power

Paper 1

1. **D**
Most of the kinetic energy will be converted into thermal energy.

Must-Know Concept:
The brake rubs against the wheel to stop the car.

2. **A**
Work done = weight × distance

$$\text{Power} = \frac{\text{work done}}{\text{time taken}}$$
$$= \frac{\text{weight} \times \text{distance}}{\text{time taken}}$$

Thus, the most power is produced by a body of a greater weight (the boy) and with less time taken (10 s).

Must-Know Concept:
$W = Fs$, $P = \frac{W}{t}$

3. **D**
Elastic potential energy is stored in the string when the string on a bow is pulled. When the arrow is shot up into the air, the elastic potential energy in the string is converted into gravitational potential energy.

Must-Know Concept:
Elastic potential energy is the energy stored in a body due to its elastic deformation.

4. **C**
Power = work done ÷ time taken
Less power is developed later in the day as the time taken is longer.

Must-Know Concept:
$P = \frac{W}{t}$

5. **D**
A hair drier is designed to blow hot air over damp hair, so most of the electrical energy is converted into thermal energy.

Must-Know Concept:
The hair drier produces mainly heat.

6. **A**
The unit of work is the joule (J).

Must-Know Concept:
Recall the unit of work.

7. **B**

$$\text{Power} = \frac{\text{work done}}{\text{time taken}}$$
$$= \frac{\text{gravitational potential energy gained}}{\text{time taken}}$$
$$= \frac{\text{weight} \times \text{height}}{\text{time taken}}$$

Hence, the height, time and weight are needed to calculate the useful power produced by the worker.

Must-Know Concept:
$P = \frac{W}{t}$

8. **A**
To calculate the work done, one needs to know the force and the distance moved by the object in the direction of the force. In this case, the distance moved by the object in the direction of the force is the vertical movement of the bricks, i.e. the height the man lifts the bricks.

Must-Know Concept:
$W = Fs$

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9. **B**

Power, $P = \frac{W}{t} = \frac{Fs}{t} = \frac{mgs}{t}$

Option A: Lifting a heavier box using the same time to the same height would need more power. (✗)

Option B: Lifting the same box to the same height within more time would need less power. (✓)

Option C: Lifting the same box using the same time to a higher position would need more power. (✗)

Option D: A motor is normally more effective than a person to lift the box, thus it would take less time for the motor to lift the same box to the same height. This would need more power. (✗)

Must-Know Concept:
$P = \frac{W}{t}$

10. **D**

Work done, $W = F \times s$

Option A: $W = 1000\ \text{N} \times 1.0\ \text{m} = 1000\ \text{J}$

Option B: $W = 1000\ \text{N} \times 1.2\ \text{m} = 1200\ \text{J}$

Option C: $W = 1200\ \text{N} \times 1.0\ \text{m} = 1200\ \text{J}$

Option D: $W = 1200\ \text{N} \times 1.2\ \text{m} = 1440\ \text{J}$ (greatest)

Must-Know Concept:
$W = Fs$

11. **C**

Must-Know Concept:
$E_p = mgh$

12. **D**

The Principle of Conservation of Energy states that energy cannot be created or destroyed, but can be converted from one form to another.

Must-Know Concept:
Recall the Principle of Conservation of Energy.

13. **A**

The gymnast's acceleration in the air is the same as the acceleration due to gravity. Gravitational potential energy is directly proportional to height. Since the gymnast bounces higher in the second time, he experiences greater gravitational potential energy. Thus, more kinetic energy can be converted, and hence his speed on contact with the trampoline is higher.

Must-Know Concept:
Gravitational potential energy is directly proportional to height.

14. **C**

$E_p = mgh$

$E_k = \frac{1}{2}mv^2$

Must-Know Concept:
Recall the formulae of E_p and E_k.

15. **C**

Total work done $= Pt$

$= 75\ \text{W} \times (4 \times 60)\ \text{s}$

$= 18\,000\ \text{J}$

Number of times $= \frac{18\,000\ \text{J}}{150\ \text{J}}$

$= 120$

Must-Know Concept:
$W = Pt$

16. **A**

The cyclist converts chemical potential energy in his body into gravitational potential energy when he pedals to the top of the hill at constant speed.

Must-Know Concept:
The kinetic energy is kept constant as there is no change in the speed.

17. **B**

Work done is the product of the force and the distance moved by the object in the direction of the force.

Must-Know Concept:
$W = Fs$

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18. **A**

Food is a form of chemical potential energy which will be converted by the body into motion which is kinetic energy.

Must-Know Concept:
Recall the different forms of energy and its conversions.

19. **A**

Work done = Force applied × Distance moved

Total work = Work on smooth ground + Work on rough ground

= (10 N × 10 m) + (20 N × 5 m)

= 200 J

Must-Know Concept:
Work Done = Force applied x Distance travelled

Paper 2

Section A

1. (a) Gravitational force

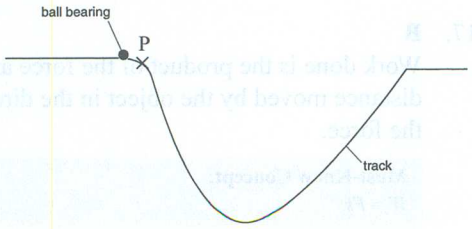
(b) The car possesses gravitational potential energy on the hill. As the car starts to run down the hill, the gravitational potential energy is converted into kinetic energy of the car.

2. (a) Since the angle made with the horizontal in the discus shown in R is smaller than that in S, the vertical displacement travelled by the discus shown in R will be smaller. Thus, less of its kinetic energy will be converted into gravitational potential energy, enabling the discus to travel over a greater horizontal distance through the air after being thrown.

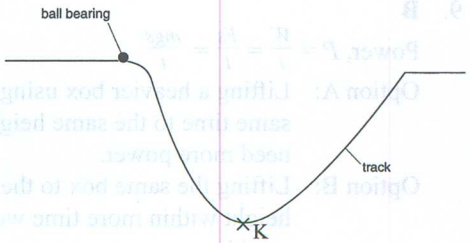
(b) (i) Y

(ii) W

3. (a)



(b)



(c) The Principle of Conservation of Energy states that energy cannot be created or destroyed but can only be converted from one form into another.

4. (a) GPE = mgh

GPE = 25 kg × 10 N/kg × 6 m

= 1500 J

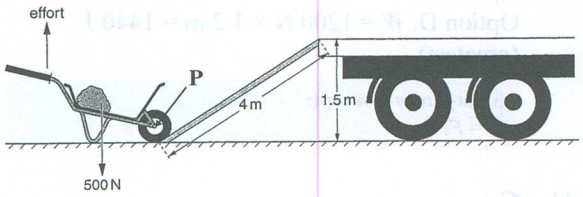
(b) $\text{Power} = \frac{\text{Work done}}{\text{Time}}$

$= \frac{1500\text{ J}}{5\text{ s}}$

= 300 W

Section B

1. (a)



(b) (i) Mr Chan's effort will need to be less than 500 N to lift the handle because the effort applied at the handle is further away from the wheel (pivot) than the rock.

(ii) 1. Place the rock closer to the wheel (pivot).

2. Apply the effort further away from the wheel (pivot). / Apply the force at the extreme end of the handle.

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(c) Work done = force × distance moved in the direction of the force
= 500 N × 1.5 m
= 750 J

(d) Kinetic energy of the wheelbarrow and the rock = $\frac{1}{2}mv^2$
$= \frac{1}{2} \times \frac{500}{10}$ kg × (2 m/s)^2
= 100 J

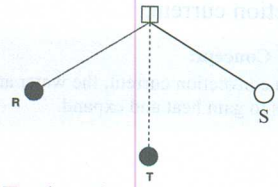
2. (a) (i) 13:00

(ii) 5:00

(b) Time for two 1500 W air-conditioner units to be used
$= \frac{24 \text{ kWh}}{2 \times 1500 \text{ W}}$
= 8 h

3. $E_k = \frac{1}{2}mv^2$
$= \frac{1}{2}$ × 5000 kg × (4.0 m/s)^2
= 4 × 10^4 J

4. (a)



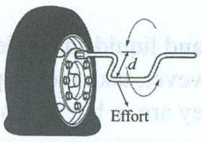
Explanation:
Assume there is no air resistance, the bob would reach the same height as R at S.

(b) Energy is conserved, so the gravitational potential energy at R is the same as the gravitational potential energy at S.

(c) The gravitational potential energy at R is converted into kinetic energy at T. The kinetic energy at T is converted into gravitational potential energy at S.

5. (a) F

Explanation:
When the distance d is increased, the effort applied can be reduced. (Moment = effort × perpendicular distance d)



(b) $\frac{1}{4}$ turn = 30 cm
1 full turn = 4 × 30 cm
= 120 cm
= 1.2 m
Work done, $W = Fs$
= 20 N × 1.2 m
= 24 J

Explanation:
Work done = force × distance moved in the direction of force

6. (a) 30°

(b) At 30°, the sum of energy received is 29.2 + 29.2 + 25.9 + 21.6 = 105.9 MJ
At 40°, the sum of energy received is 27.4 + 27.4 + 26.3 + 22.3 = 103.4 MJ
Hence, at 30°, the panels will receive the most energy.

(c) In May at an angle of 30°, energy received by 1 m^2 is 28.8 MJ
max energy received
= 28.8 MJ × 3 m^2 × 10 panels
= 864 MJ

TOPIC 8 Kinetic Model of Matter

Paper 1

1. **C**
Particles in air move randomly, i.e. they are in Brownian motion.

Must-Know Concept:
Particles in air move in Brownian motion.

2. **B**
When the solid is heated and turns into a gas, the temperature increases. The distance between the particles becomes larger and the particles are arranged in a disorderly manner.

Must-Know Concept:
When the temperature of the air increases, the particles move faster and collide more frequently.

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3. **A**
Both solids and liquids have definite volume. Liquids, however, take the shape of the container they are in but solids do not.

Must-Know Concept:
Liquids do not have definite shape.

4. **A**
When the air is heated, the air molecules have greater average speed. The molecules then collide more vigorously and more frequently with the inner surface of the cylinder. A net force acting on the piston causes it to move to the right. Thus, the volume of air increases.

Must-Know Concept:
When the temperature of the air increases, the particles move faster and change direction more frequently.

5. **C**
The gas molecules that make up the gas are always in continuous random motion. When the temperature of the gas increases, the average kinetic energy of the gas molecules increases.

Must-Know Concept:
When the temperature of the gas increases, the gas molecules move faster and change direction more frequently.

6. **C**
Heating will cause the molecules to gain in kinetic energy, hence, increasing their velocity.

Must-Know Concept:
Recall the effect of heat on molecules.

Paper 2

Section A

1. Solid has molecules that are closely and regularly packed together.

TOPIC 9 Transfer of Thermal Energy

Paper 1

1. **D**
Shiny surfaces are bad emitters of infra-red radiation.

Must-Know Concept:
White, shiny and smooth surfaces are bad emitters and absorbers.

2. **D**
A black surface is a good emitter of radiation, allowing it to assist in heat loss of objects.

Must-Know Concept:
Black, dull and rough surfaces are good emitters and absorbers.

3. **C**
Black surfaces are good absorbers and good emitters of heat. A refrigerator needs to lose heat to the surroundings through the cooling fins in order to keep the contents inside cool. Hence, the cooling fins are painted black to emit heat more efficiently.

Must-Know Concept:
Black, dull and rough surfaces are good emitters and absorbers.

4. **D**
When the water above position D is heated, it expands. As the water above position D is less dense than the surrounding water, it rises. The denser surrounding water then flows and replaces the water that has left above position D. The difference in the densities of water sets up a convection current.

Must-Know Concept:
To produce a convection current, the water at the bottom needs to gain heat and expand.

5. **C**
Before heating, the atoms of the metal fork are vibrating normally at their positions. When heated, the atoms at the hot end vibrate rapidly. Then they collide and transfer the energy to the neighbouring atoms, making them vibrate rapidly. Eventually, the atoms at the other end are also set into rapid vibration and the heat is conducted to the boy's hand.

Must-Know Concept:
More energetic particles collide with neighbouring particles to transfer the thermal energy.

6. **A**
The temperature in box X becomes higher after a long time as heat is conducted from the warm kitchen stove to the box. The temperature in box Y does not change much as it is placed on the table at room temperature. At higher

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temperature, the average kinetic energy of the air molecules increases. Thus, the air molecules move faster. The molecules in box Y are moving but their speed is lower than that of the molecules in box X.

Must-Know Concept:
The temperature in box X becomes higher than that in box Y after a long time.

7. **D**
The heat of both hot water in the two cans is mainly transferred to the surroundings through the cans by conduction. Thus, their temperatures gradually decrease with time. However, the insulated can is a poor conductor of heat, so the temperature of hot water in the insulated can decreases slower than that in the uninsulated can.

Must-Know Concept:
An insulated can means the can is wrapped by a poor conductor of heat.

8. **D**
Shiny surfaces are poor emitters of infra-red radiation.

Must-Know Concept:
White, shiny and smooth surfaces are poor emitters and absorbers.

9. **A**
Initially water in all the copper containers is at higher temperature and hence, radiation will occur. Dull black coating is a good radiator of thermal energy. Without the lid, effective cooling by convection is allowed as convection involves bulk movement of fluids and hence, fluids will be able to move or circulate for convection to happen.

Must-Know Concept:
Recall what radiation is and how the surface affects it; and how convection can be more effective.

Paper 2

Section A

1. (a) Conduction

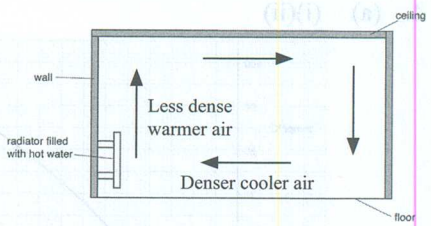
Explanation:
Heat conduction occurs through solids.

(b) (i) Convection

Explanation:
Heat is transmitted the fastest by convection in fluids (liquid and gas).

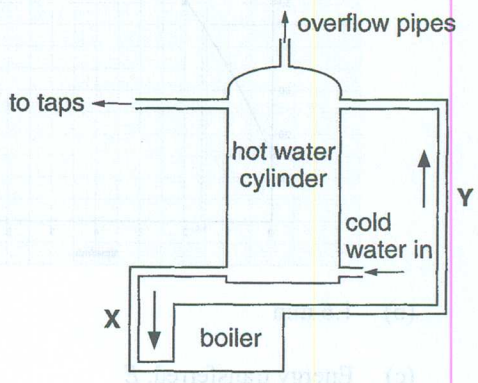
(ii) The air heated up by the radiator is less dense than the cooler surrounding air. The denser cooler air pushes the less dense hotter air up, thereby setting up a convection current that warms up the whole room.

Explanation:
The diagram below shows the convection current in the room.



Section B

1. (a)



(b) Convection in liquids

(c) Process: Radiation
Reason: Radiation is the transfer of thermal energy without a medium. Since the space between the Sun and the Earth is a vacuum, the transfer of thermal energy from the Sun to the Earth is by radiation.

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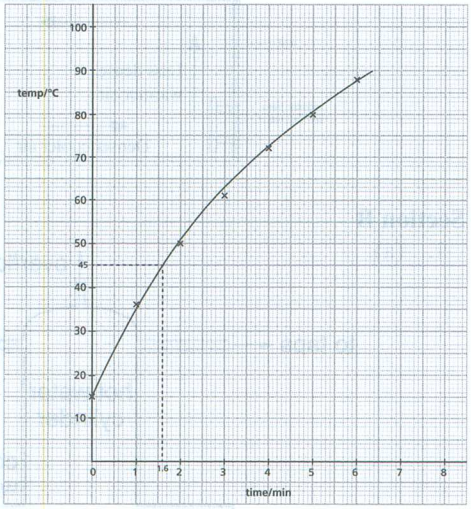
2. Process: Convection
Explanation: When the water at the bottom of the cup is heated, it expands. The expanded water is less dense than the surrounding water and starts to rise. The cooler water in the upper part of the cup, being denser, sinks to the bottom of the cup. A convection current is set up and the water at the top becomes hotter than the water at the bottom.

3. Process: Radiation
Reason: As the Sun and the Earth are separated by a vacuum, radiation is the only major process for heat to be transferred from the Sun to the objects on the Earth without the aid of a medium.

4. (a) (i)(ii)



(b) 1.6 min

(c) Energy transferred, E
$= Pt$
$= 1000\ \text{W} \times (1.6 \times 60)\ \text{s}$
$= 9.6 \times 10^4\ \text{J}$

(d) Convection

(e) Colour and texture: Shiny and silver
Reason: This type of heat loss occurs through radiation. A shiny and silver surface is not a good emitter and absorber of infra-red radiation, so it is able to keep heat loss through radiation to a minimum.

5. conduction: Heat is transferred from the hot plate to the metal pan and to the water by conduction. Since both the plate and the pan are made of metals, the conduction occurs via vibration of particles and free electron diffusion.
convection: The water is heated by the process of convection. When the water at the bottom of the pan is heated, its density decreases and it rises. The upper region of the water is denser and cooler and therefore it sinks. The difference in the densities of water at the different regions sets up a convection current.

6. (a) Radiation

(b) colour: Black
explanation: Black is a good absorber of radiation.

(c) Panel design **A** requires the cold water to flow through a long coil of tubing that is in contact with the hot absorbing surface. The long coil enables the water to stay in contact with the surface for a longer duration, allowing more time for thermal energy transfer from the hot surface to the cool water. This can heat up the water more effectively.

(d) inlet pipe: N
reason and explanation: Hot water is less dense compared to cold water and hence, will float above cold water. When water enters through inlet N, the warm water can rise up the tank while cool water sinks. This enables a better mixing of the warm and cool water, allowing the pool in the water to be more evenly warmed.

TOPIC 10 Thermal Properties of Matter

Paper 1

1. **D**
Melting and boiling occur without a change in temperature.

Must-Know Concept:
There is no change in temperature during melting and boiling.

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2. **C**

During evaporation, the water molecules at the water surface are more energetic as they absorb thermal energy from the surroundings. Hence, they are able to overcome the attractive forces of other molecules and escape from the surface.

Must-Know Concept:
Evaporation only takes place on the surface of the liquid.

3. **D**

Boiling is a heat gaining process which involves a change of state of a substance from the liquid state to the gaseous state without a change in temperature.

Must-Know Concept:
There is no change in temperature during boiling.

4. **D**

Melting and boiling occur without a change in temperature.

Must-Know Concept:
There is no change in temperature during melting and boiling.

5. **C**

Evaporation takes place only at the liquid surface. When evaporation occurs, the average temperature of the liquid decreases.

Must-Know Concept:
Evaporation only takes place at the surface of the liquid. The average temperature of the remaining liquid decreases when evaporation occurs.

6. **A**

Amount of heat needed to increase the temperature of the block by 1°C

$= \frac{Q}{\Delta\theta}$

$= \frac{80\text{ J}}{20°\text{C}}$

$= 4\text{ J/°C}$

Amount of heat needed to increase the temperature of the block by 10°C

$= C\Delta\theta$

$= 4\text{ J/°C} \times (10°\text{C})$

$= -40\text{ J}$

Must-Know Concept:
$Q = C\Delta\theta$

7. **B**

The hot drink possesses more heat than the surroundings, thus it loses heat to the surroundings. Thus, the amount of vibration or movement of the particles decreases, which leads to a fall in its temperature.

Must-Know Concept:
When matter loses thermal energy, its internal energy decreases.

8. **B**

During melting, the temperature of the ice stays constant. However, as ice absorbs thermal energy from the warm water, the water loses thermal energy and its temperature decreases. Thus, its internal energy decreases.

Must-Know Concept:
When matter loses thermal energy, its internal energy decreases.

9. **B**

Liquids in general have no fixed shape but have fixed volumes.

Must-Know Concept:
Know the physical properties of substances in the three states of matter.

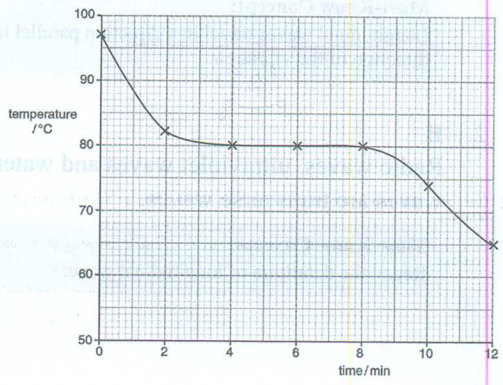
Paper 2

Section A

1. (a)

Time / min	Temperature / °C
0	97
2	82
4	80
6	80
8	80
10	74
12	65

(b) (i)



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(ii) 80°C

2. (a) Carbon dioxide

   (b) 800°C

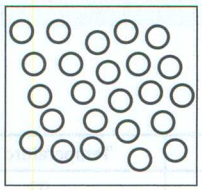
3. During the period of 4 to 8 minutes, temperature is constant at 50°C, indicating that the wax is melting. Energy supplied to the wax is changing the wax from a solid state to a liquid state. At 4 minutes, the wax has started melting and by the time it is 8 minutes, the wax has fully melted and is in the liquid state.

Section B

1. (a) 34°C

   (b) 18°C

   (c) The liquid cools to become a solid at 34°C. Its temperature then continues decreasing until it reaches the temperature of the laboratory and becomes a constant, which is 18°C.

   (d) 

TOPIC 11 General Wave Properties

Paper 1

1. **C**
   Longitudinal waves, such as sound waves, travel in the direction parallel to the direction of vibration.

   Must-Know Concept:
   Longitudinal waves travel in a direction parallel to the direction of the vibration.

2. **B**
   Radio waves, ultraviolet waves and water waves are transverse waves.

   Must-Know Concept:
   Recall the definition of longitudinal wave.

3. **B**
   Light waves, water waves and X-ray waves are transverse waves. Sound waves are longitudinal waves.

   Must-Know Concept:
   Recall the definition of longitudinal wave.

4. **B**
   Frequency is the number of oscillations in one second and is measured in Hertz. Hence, the 100 MHz is the frequency of the radio waves.

   Must-Know Concept:
   Hertz is the unit of frequency.

5. **C**
   Transverse waves are waves that travel perpendicular to the direction of the vibration. Longitudinal waves are waves that travel parallel to the direction of the vibration.

   Must-Know Concept:
   Longitudinal waves travel in a direction parallel to the direction of the vibration. Transverse waves travel in a direction perpendicular to the direction of the vibration.

6. **D**
   Wave speed is the distance travelled by a wave per second. For a transverse wave such as water wave, it can be defined by the distance that a wavefront moves along the surface in one second.

   Must-Know Concept:
   Wave speed is defined as the distance travelled by a wave per second.

7. **D**
   The spring moves up and down in a transverse wave while the spring moves forward and backward in a longitudinal wave.

   Must-Know Concept:
   Longitudinal waves travel in a direction parallel to the direction of the vibration. Transverse waves travel in a direction perpendicular to the direction of the vibration.

8. **A**
   With the ruler placed in this position, the maximum displacement of the equilibrium position to a crest can be measured.

   Must-Know Concept:
   The amplitude of a wave is the maximum displacement of a point from its rest position.

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9. **C**

A wavefront is an imaginary line that joins all the particles (or points) that oscillate in phase.

Must-Know Concept:
Recall the definition of wavefront.

Paper 2

Section A

1. (a) amplitude

   (b) wavelength

   (c) velocity = frequency × wavelength

2. (a) 5 cm

   (b) 1.8 cm

   (c) $v = f\lambda$

   $f = \frac{v}{\lambda}$

   $f = \frac{20 \text{ cm/s}}{5 \text{ cm}}$

   $= 4 \text{ Hz}$

3. (a) A wavefront is an imaginary line on a wave that joins all adjacent points that are in phase.

   (b) Wavelength, $\lambda = \frac{10 \text{ cm}}{5}$

   $= 2 \text{ cm}$

   (c) 1. Period, $T = \frac{0.2 \text{ s}}{2}$

   $= 0.1 \text{ s}$

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

   $= \frac{1}{0.1 \text{ s}}$

   $= 10 \text{ Hz}$

   2. Speed, $v = f\lambda$

   $= 10 \text{ Hz} \times 2 \text{ cm}$

   $= 20 \text{ cm/s}$

Section B

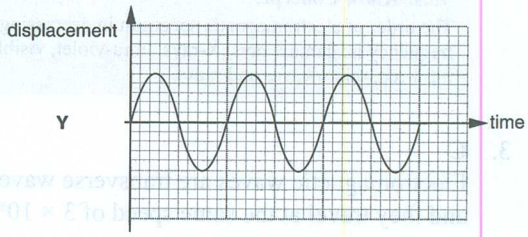
1. (a) (i) AB AO CF OD

   (ii) AC CB OE OD

   (iii) Period is the time taken to produce a complete wave.

   (b) (i) A wavefront is an imaginary line joining all points of the wave that are in the same phase.

   (ii)



2. (a) (i) Wavefront

   (ii) Wavelength

   (b) (i) Speed, $v = \frac{d}{t}$

   $= \frac{1.2 \text{ m}}{4 \text{ s}}$

   $= 0.3 \text{ m/s}$

   (ii) Wavelength, $\lambda = \frac{v}{f}$

   $= \frac{0.3 \text{ m/s}}{3 \text{ Hz}}$

   $= 0.1 \text{ m}$

3. wavelength: E

   amplitude: C

TOPIC 12 Electromagnetic Spectrum

Paper 1

1. **C**

   According to the electromagnetic spectrum, electromagnetic waves are listed in order of increasing frequency as follows: radiowaves, microwaves, infra-red, visible light, ultra-violet, X-rays and gamma rays.

   Must-Know Concept:
   The order of electromagnetic spectrum in increasing frequency is: radio, microwaves, infra-red, visible, ultra-violet, X-rays and gamma rays.

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2. **C**
Wave 'W' represents infra-red. Electromagnetic waves, including infra-red, are transverse waves. They travel at the same speed as light.

Must-Know Concept:
The order of electromagnetic spectrum in decreasing frequency is: gamma rays, X-rays, ultra-violet, visible, infra-red, microwaves and radio.

3. **C**
Electromagnetic waves are transverse waves and they travel at the same speed of 3×10^8 m/s in vacuum.

Must-Know Concept:
Electromagnetic waves are transverse waves.

4. **D**
Both visible light and gamma rays are electromagnetic waves. Thus, they are transverse waves.

Must-Know Concept:
Electromagnetic waves are transverse waves.

5. **D**
Electromagnetic waves are transverse waves that can travel through vacuum (such as outer space) and travel through air (like how light travel in air).

Must-Know Concept:
Recall characteristics of electromagnetic waves.

Paper 2

Section A

1. (a) infra-red
   (b) X-ray
   (c) ultra-violet

Section B

1. Radio waves/Microwaves/Infra-red/Ultraviolet/X-rays/Gamma rays (*Any two*)

TOPIC 13 Sound

Paper 1

1. **D**
The frequency of a sound is the number of complete sound waves produced per second.

Must-Know Concept:
Recall the definition of frequency.

2. **D**
Pitch is related to the frequency while loudness is related to the amplitude. Sound 1 has the same amplitude as sound 2 but has a higher frequency, thus it has a higher pitch.

Must-Know Concept:
Pitch depends on frequency while loudness depends on amplitude.

3. **B**
Time interval between hearing the two sounds
$= \frac{150 \text{ m} + 150 \text{ m}}{300 \text{ m/s}} - \frac{150 \text{ m}}{300 \text{ m/s}}$
$= 0.50$ s

Must-Know Concept:
Time interval = time taken for the sound to travel from X to the wall then reflected to Y – time taken for the sound to travel from X to Y directly

4. **D**
Both waves have the same amplitude but different frequencies. Thus, they have the same loudness but different pitch.

Must-Know Concept:
Loudness is related to amplitude while pitch is related to frequency.

5. **A**
From the graph, P has a larger amplitude but a lower frequency. Thus, it is louder and has a lower pitch.

Must-Know Concept:
Loudness is related to amplitude while pitch is related to frequency.

6. **B**
Total distance travelled by sound (to and fro)
= Speed of sound × Time
= 1500 m/s × 0.80 s
= 1200 m
Depth $= \frac{1200 \text{ m}}{2}$
$= 600$ m

Must-Know Concept:
Distance = Speed × Time;
The formation of echo requires sound to travel to and fro.

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Paper 2

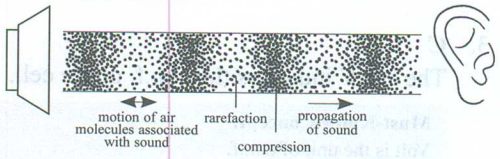
Section A

1. (a) Sound T
Loudness is related to the amplitude of a sound. A sound with a larger amplitude is louder. Based on the diagram, the amplitude of sound T is the largest. Thus, it is the loudest.

(b) Sound R
Pitch is related to the frequency of a sound. A sound with a higher frequency has a higher pitch. Based on the diagram, the frequency of sound R is the lowest. Thus, it has the lowest pitch.
Explanation:
R makes a complete wave in 2 units while S and T make a complete wave in 1 unit.

2. (a) Sound waves are propagated by air molecules that vibrate to and fro in the direction of wave travel. As a result, a series of compressions and rarefactions travel from the source of vibration to the ear.

Explanation:



(b) frequency = 2000 Hz
reason: At 2000 Hz, both the 13-year-old person and 65-year-old person are able to register the sounds as the loudest they can hear.

Section B

1. Frequency, $f = \frac{v}{\lambda}$

$= \frac{330 \text{ m/s}}{33 \text{ cm}}$

$= \frac{33\,000 \text{ cm/s}}{33 \text{ cm}}$

$= 1000 \text{ Hz}$

2. (a) (i) C represents compression and R represents rarefaction.

(ii) There are no air particles in a vacuum to transfer the energy of a sound wave.

(iii) The particles in iron are more closely packed as compared to the arrangement of particles in water.

(b) (i) Echo

(ii) $d = v \times t$

$= \frac{1500 \text{ m/s} \times 0.1 \text{ s}}{2}$

$= 75 \text{ m}$

(c) 1. The amplitude of sound S1 is lower than that of sound S2. Hence, sound S1 is softer than sound S2.

2. The frequency of sound S1 is lower than that of sound S2. Hence, sound S1 has a lower pitch than sound S2.

3. (a) When the trigger is pulled, the starting pistol produces vibrations in air, causing air particles around it to be displaced. This displacement of particles causes sound waves to propagate until they reach the ears of the people recording the times of the race.

(b) Longitudinal wave

4. (a) (i) The sound of the bell becomes faint and disappears, even though the striker is still hitting the bell.

(ii) Being suspended by an elastic band ensures that the transmission of the sound is minimised as the elastic band is not an effective medium to transmit sound. If the bell is placed on the base plate, the sound can be transmitted by the vibration of particles in the base plate.

(b) (i) Distance travelled by the pulse of the sound,
$d = vt$
$= 1500 \text{ m/s} \times 0.10 \text{ s}$
$= 150 \text{ m}$

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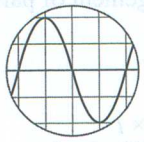
(ii) Distance of the shoal of fish from the boat, $d' = \frac{d}{2}$

$= \frac{150 \text{ m}}{2}$

$= 75 \text{ m}$

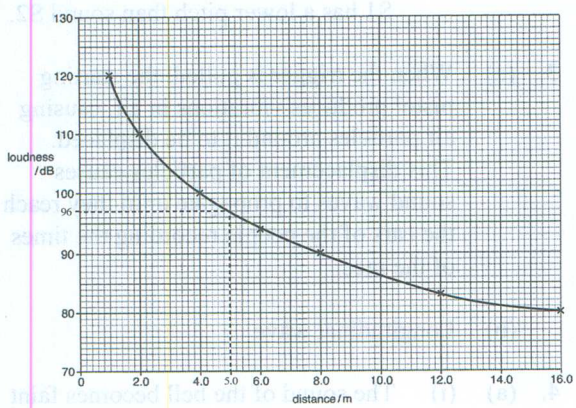
5. (a) (i)



trace B

(ii) Trace C shows a sound with a half the period of trace A. Hence, trace C has double the frequency of trace A. When a sound has a higher frequency, it has a higher pitch.

(b) (i)(ii)



(iii) loudness of sound = 96 dB

(iv) Based on the table, since the sound is 97 dB when the man is 5.0 m away from the loudspeaker, length of time = 30 minutes

(v) Wear earplugs that can muffle or reduce the loudness of the sound while standing in front of the loudspeaker.

TOPIC 14 Current Electricity

Paper 1

1. **B**

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

Option A: Resistance $= \frac{110 \text{ V}}{5.0 \text{ A}}$

$= 22 \ \Omega$

Option B: Resistance $= \frac{110 \text{ V}}{10.0 \text{A}}$

$= 11 \ \Omega$

Option C: Resistance $= \frac{230 \text{ V}}{5.0 \text{ A}}$

$= 46 \ \Omega$

Option D: Resistance $= \frac{230 \text{ V}}{10.0 \text{ A}}$

$= 23 \ \Omega$

Must-Know Concept:
$R = \frac{V}{I}$

2. **D**

Electromotive force (e.m.f) is measured in volts.

Must-Know Concept:
Volt is the unit of e.m.f.

3. **C**

The 1.5 V indicates the e.m.f. of the cell.

Must-Know Concept:
Volt is the unit of e.m.f.

4. **C**

Resistance = potential difference ÷ current

Must-Know Concept:
$R = \frac{V}{I}$

5. **A**

Conventional current is defined as the flow of electric current from the positive end to the negative end of an electric source, as indicated by arrows P and R. Electron flow is defined as the movement of electrons from the negative end to the positive end of an electric source, as indicated by arrows Q and S.

Must-Know Concept:
The direction of conventional current is from the positive terminal to the negative terminal of a power source while the direction of electron flow is the opposite.

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6. **C**

The resistance of a wire is directly proportional to its length and inversely proportional to its diameter.

Must-Know Concept:
The resistance of a wire is directly proportional to its length but inversely proportional to its cross-sectional area.

7. **B**

An electron flow is caused by the flow of electrons from the negative terminal to the positive terminal. A conventional current flows in the direction opposite to electron flow.

Must-Know Concept:
The direction of conventional current is from the positive terminal to the negative terminal of a power source while the direction of electron flow is the opposite.

8. **B**

Resistance of a copper wire is directly proportional to its length and inversely proportional to its cross-sectional area. As the wire in option B is shorter and has a bigger cross-sectional area (larger diameter), it has the least resistance.

Must-Know Concept:
The resistance of a wire is directly proportional to its length but inversely proportional to its cross-sectional area.

9. **C**

The electrons flow from a negatively-charged terminal to a positively-charged terminal.

Must-Know Concept:
The direction of electron flow is from the negative terminal to the positive terminal of a power source.

10. **A**

Since the resistance of the resistor does not change, the resistor obeys Ohm's Law. Thus, the graph is a straight line that passes through the origin.

Must-Know Concept:
The resistor obeys Ohm's Law.

11. **C**

By Ohm's Law, increasing the p.d. across the resistor and decreasing the resistance of the resistor will both increase the current in the resistor.

Must-Know Concept:
$R = \frac{V}{I}$

12. **B**

Option A: The voltmeter does not work as S_2 is open. (✗)
Option B: The voltmeter measures the p.d. across the resistor (12 V). (✓)
Option C: The voltmeter measures the d.c. power supply (12 V). (✗)
Option D: The voltmeter does not work as S_2 is open. (✗)

Must-Know Concept:
A voltmeter must be connected in parallel to the resistor to measure its voltage.

13. **B**

$Q = It$
$= 4.0\text{ A} \times 20\text{ s}$
$= 80\text{ C}$

Must-Know Concept:
$Q = It$

14. **C**

The resistance of a wire is directly proportional to its length but inversely proportional to its cross-sectional area. Since the wire in option C is short and has a big cross-sectional area, it has the smallest resistance.

Must-Know Concept:
The resistance of a wire is directly proportional to its length but inversely proportional to its cross-sectional area.

15. **B**

$$\text{e.m.f.} = \frac{W_1}{Q} + \frac{W_2}{Q}$$
$$= \frac{6\text{ J}}{2\text{ C}} + \frac{6\text{ J}}{2\text{ C}}$$
$$= 6\text{ V}$$

Must-Know Concept:
$\varepsilon = \frac{W}{Q}$

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16. **C**

$$\text{Current} = \frac{\text{Charge}}{\text{Time}}$$

It is the amount of charges that pass through a point per unit time or the rate of flow of charges.

Must-Know Concept:
Recall definition of current.

Paper 2

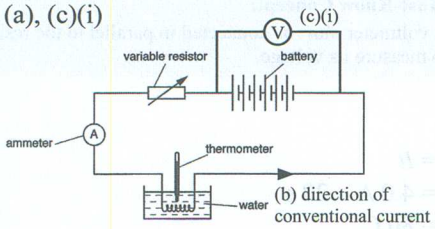
Section A

1. (a) U and W

Explanation:
Only vary the length of the wire. Keep the material and cross-sectional area the same.

(b) U

2. (a), (c)(i)



(b) (ii) Current, $I = \frac{Q}{t}$

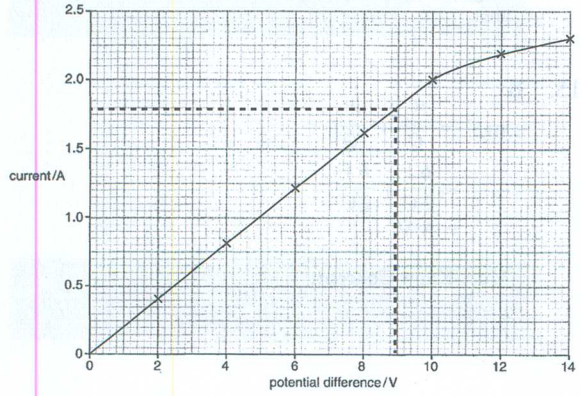
$$= \frac{60\text{ C}}{2 \times 60\text{ s}}$$
$$= 0.5\text{ A}$$

Section B

1. (a) (i) Variable resistor

(ii) The variable resistor is used to vary the amount of current in the circuit.

(b) (i)



(ii) 9 V

(iii) The resistance is constant from 0 V to 10 V. It increases at an increasing rate from 10 V onwards.

(iv) $R = \frac{V}{I}$

$$= \frac{8.0\text{ V}}{1.6\text{ A}}$$
$$= 5\ \Omega$$

2. (a) (i) Variable resistor / Rheostat

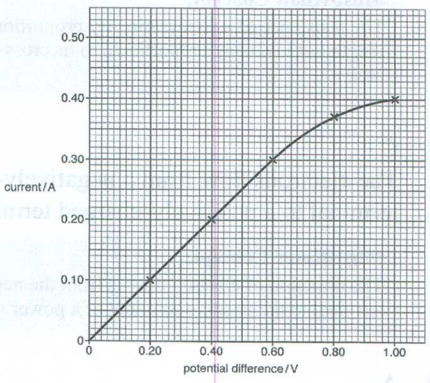
(ii)

p.d. reading $\frac{V}{\text{V}}$	current reading $\frac{I}{\text{A}}$	$\frac{V}{I}$ / Ω
0.20	0.10	2.0
0.40	0.20	2.0
0.60	0.30	2.0
0.80	0.40	2.0
1.00	0.50	2.0

resistance of wire U = 2.0 Ω

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

(b) (i)



(ii) The graph of I against V for wire V is not a straight line, so wire V does not follow Ohm's Law.

Explanation:
Ohm's Law states that the potential difference across a component is directly proportional to the current flowing through it.

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(c) Effective resistance of the two resistors in parallel

$= \left(\frac{1}{4\,\Omega} + \frac{1}{6\,\Omega}\right)^{-1}$

$= \left(\frac{10}{24\,\Omega}\right)^{-1}$

$= \frac{24}{10}\,\Omega$

$= 2.4\,\Omega$

Combined resistance of the three resistors

$= 3\,\Omega + 2.4\,\Omega$

$= 5.4\,\Omega$

Explanation:

Effective resistance of two resistors in parallel $= \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$

3. (a) (i) Ammeter

(ii) resistor: S has a larger resistance
explanation: the current passing through resistor S is smaller

(b) Lamp M is ohmic in nature as *V*-*I* graph is a straight line with a constant gradient. Resistance of M is the gradient of the graph.

The resistance of M is given by:

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

$R = \frac{1.0}{0.4}$

$= 2.5\,\Omega$

TOPIC 15 D.C. Circuits

Paper 1

1. **C**

Since both lamps are of equal resistance, A_2 and A_3 will have the same amount of current flowing through them.

Must-Know Concept:
The identical lamps are connected in parallel.

2. **C**

The variable resistor is able to control the amount of current flowing through the lamp. Hence, the circuit in option C could be used to vary the brightness of a lamp.

Must-Know Concept:
The amount of the current in the circuit needs to be varied to change the brightness of the lamp.

3. **A**

In a parallel circuit, the potential difference across each separate branch is the same as the electromotive force (e.m.f.) of the battery.

Must-Know Concept:
The p.d. across separate parallel branches is the same.

4. **C**

The currents at points A, B and D are the same (2 A) as they flow through the main circuit. The current at point C is less than 2 A as it flows through a separate branch of a parallel circuit.

Must-Know Concept:
The current splits up in the parallel circuit.

5. **A**

To vary the brightness of the lamp, the amount of the current in the circuit needs to be varied. This can only be realised by connecting a variable resistor in the circuit.

Must-Know Concept:
The amount of the current in the circuit needs to be varied to change the brightness of the lamp.

6. **B**

The electron flow is from the negatively-charged terminal to the positively-charged terminal. The conventional current is in the direction opposite to electron flow.

Must-Know Concept:
The direction of conventional current is from the positive terminal to the negative terminal of a power source while the direction of electron flow is the opposite.

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7. **A**

Only in option A are all the three lamps able to work under 240 V. Thus, all are lit at their normal brightness.

Must-Know Concept:
In a parallel circuit, the potential differences across each branch are the same.

8. **D**

When the switch is closed, the two resistors are connected in parallel.

$I_A = I_1 + I_2$

$= \frac{6.0\text{ V}}{3.0\ \Omega} + \frac{6.0\text{ V}}{2.0\ \Omega}$

$= 5.0\text{ A}$

Must-Know Concept:
The main current is equal to the sum of the individual current in each of the parallel branches.

9. **C**

If switch A or B is opened, all the lamps will go out. If switch C is opened, one lamp will go out. If switch D is opened, two lamps will go out.

Must-Know Concept:
The switch on the main circuit controls all the lamps while the switch on each branch controls the lamps on that branch.

10. **C**

The reading on ammeter 2 is the same as that of ammeter 1.

Must-Know Concept:
Both ammeters are connected to the main circuit.

11. **D**

$\frac{1}{R''} = \frac{1}{Y} + \frac{1}{Z}$

$R'' = \frac{1}{\frac{1}{Y} + \frac{1}{Z}}$

$R_{total} = X + R''$

$R_{total} = X + \frac{1}{\frac{1}{Y} + \frac{1}{Z}}$

Must-Know Concept:
Recall the steps involved in calculating resistance of resistors arranged in series and parallel.

12. **D**

Lamps 1 and 2 are arranged in parallel and directly across the battery.
Hence, voltage across battery = voltage across each parallel branch

Must-Know Concept:
In a parallel circuit, the e.m.f. (or voltage) of battery = voltage across the branches that are across the battery

Paper 2

Section A

1. (a) M2

(b) (i) Parallel

(ii) $\frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2\ \Omega} + \frac{1}{4\ \Omega}$

$= \frac{3}{4\ \Omega}$

Combined resistance $= \frac{4\ \Omega}{3}$

$= 1\frac{1}{3}\ \Omega$

(iii) Total resistance $= 3\ \Omega + 1\frac{1}{3}\ \Omega$

$= 4\frac{1}{3}\ \Omega$

2. (a) Parallel

(b) $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{1}{R} = \frac{1}{3\ \Omega} + \frac{1}{6\ \Omega}$

$R = 2\ \Omega$

(c) $V = IR$

$= 6\text{A} \times 2\ \Omega$

$= 12\text{ V}$

Section B

1. (a) (i) In series

(ii) In parallel

(b) Total voltage of the battery $= 3 \times 2\text{ V}$

$= 6\text{ V}$

(c) (i) $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{1}{R} = \frac{1}{4\ \Omega} + \frac{1}{4\ \Omega}$

Combined resistance, $R = 2\ \Omega$

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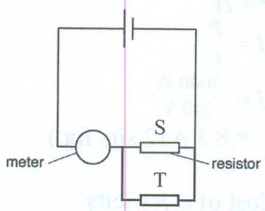
(ii) Total combined resistance
$= 3\ \Omega + 2\ \Omega$
$= 5\ \Omega$

(d) $\text{Current} = \dfrac{\text{Total e.m.f.}}{\text{Total combined resistance}}$
$= \dfrac{6\ \text{V}}{5\ \Omega}$
$= 1.2\ \text{A}$

2. (a) (i) S and T are arranged in series in a circuit. Current in a circuit with resistors arranged in series is the same. Hence, when the meter is moved to various positions in the circuit, the current reading is the same.

(ii) The reading on the meter of (a) (i) will be smaller than the readings in the table shown. This is because the effective resistance of resistors arranged in series add up to a larger value compared to the individual resistors. Effective resistance in the circuit of (a) (i) is higher and hence current value is smaller.

(b)



TOPIC 16 Practical Electricity

Paper 1

1. **B**
A circuit breaker is connected in the live wire and operates an electromagnet to break the circuit when overloaded. A fuse will melt to break the circuit when overloaded.

Must-Know Concept:
A circuit breaker is connected to the live wires of the electrical circuit.

2. **C**
When an electric cable carries too much current, it will cause the wire to overheat. Hence, the wire may become too hot and cause a fire.

Must-Know Concept:
Overheating will occur if there is too much current flowing through the cables.

3. **A**
The longest pin is connected to the earth wire.

Must-Know Concept:
Recall the structure of a three-pin plug.

4. **C**
The maximum current that the wire is designed to take is 5 A.
Maximum power output of the circuit,
$P = VI$
$= 230\ \text{V} \times 5\ \text{A}$
$= 1150\ \text{W}$
$1150\ \text{W} \div 100\ \text{W} = 11.5$
Hence, the maximum number of lamps that can be connected to the circuit is 11.

Must-Know Concept:
The lamps are connected in parallel.

5. **D**
A fuse and a switch must be connected to a live wire to cut off the current to an appliance in the event of an electrical fault.

Must-Know Concept:
A fuse must be connected in series with the live wire.

6. **D**
A circuit breaker is an automatically operated electrical switch. It can switch off the electrical supply in a circuit when the current exceeds a certain limit, protecting the circuit from damage.

Must-Know Concept:
A circuit breaker will switch off the electrical supply when there is a surge of current flowing through it.

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7. **A**

A thicker copper cable has a lower resistance that generates less heat, preventing the cable from overheating.

Must-Know Concept:
A cable with lower resistance generates less heat.

8. **C**

An electric cable carrying too much current could generate excess heat and eventually cause a fire. Electric shock can be caused when the exposed conducting cable is touched.

Must-Know Concept:
Overheating will occur if there is too much current flowing through the cables.

9. **C**

The part of insulation touching the cable grip is the white insulation. Point P is connected to the neutral wire. The neutral wire is the wire covered in blue insulation.

Must-Know Concept:
Point P is connected to the neutral wire.

10. **C**

The current supplied by the heater is greater than the current the wire is designed to carry. The excessive current flow will cause the wire to become overheated and cause a fire.

Must-Know Concept:
A current greater than its rating will cause the wire to overheat.

11. **B**

Wire P is the neutral wire (which is blue), wire Q is the earth wire (which is green and yellow striped), and wire R is the live wire (which is brown).

Must-Know Concept:
Recall the wiring in a mains plug.

12. **C**

Lamps are connected in parallel in the house.
Power of each lamp = Voltage × Current through each lamp
$100\ \text{W} = 230\ \text{V} \times I$
$I = 0.435\ \text{A}$ (current through each branch and each lamp)

$$\text{Number of lamps} = \frac{5\ \text{A}}{0.435\ \text{A}}$$
$$= 11.5$$

Hence maximum number of lamps
= 11 (cannot exceed fuse rating)

Must-Know Concept:
Calculation of power = Voltage × Current
Lamps are connected in parallel in the home electric circuit, hence, sum of current in each lamp = current in mains.

Paper 2

Section A

1. (a) (i) Y

(ii) Name: Fuse
Function: The fuse will melt and disconnect the circuit when the current flowing through it exceeds its rated value.

(b) (i) $P = IV$

$$I = \frac{P}{V}$$
$$I = \frac{2000\ \text{W}}{240\ \text{V}}$$
$$= 8.3\ \text{A (2 sig. fig.)}$$

(ii) Cost of electricity
$$= 2\ \text{kW} \times \frac{20}{60}\ \text{h} \times 30\ \text{cents}$$
$$= 20\ \text{cents}$$

2. (a) From the table, the greater the diameter of the wire, the larger is the maximum power rating and hence the maximum current it can carry.

Explanation:
The power rating is related to the maximum current by the formula $P = IV$.

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(b) (i) 1.25 mm

Explanation:
A 2750 W kettle allows a greater maximum current to flow than a 2400 W kettle.

(ii) The current that flows through a 2750 W kettle would exceed the maximum current that the wire of diameter 1.00 mm can safely carry and the wire would melt.

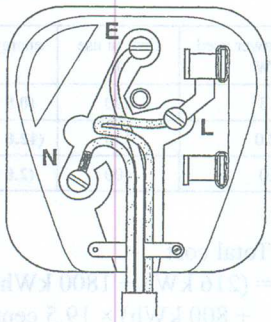
3. (a) Heating

(b) Water heater/boiler

Section B

1. (a) S

Explanation:



(b)

wire	colour of insulation
earth	**green and yellow**
live	**brown**
neutral	**blue**

(c) (i) The earth wire is connected to the metal plate of the electric iron.

(ii) The earth wire is connected to the metal plate of the iron so that if the live wire of the iron touches the metal plate, the current will flow to the earth. Hence, it will prevent users from experiencing an electric shock.

(d) (i) Current, $I = \frac{P}{V}$

$= \frac{1500\ \text{W}}{250\ \text{V}}$

$= 6\ \text{A}$

(ii) Cost of electricity
$= 1.5\ \text{kW} \times 6\ \text{h} \times 15$ cents
$= 135$ cents

2. (a) (i) Y

(ii) The earth wire has to be connected to the metal casing of the electrical appliances to divert large currents to the ground in the event of an electrical fault. This prevents a person from getting an electric shock when touching the faulty electrical appliance.

(b) (i) Current, $I = \frac{P}{V}$

$= \frac{3000\ \text{W}}{240\ \text{V}}$

$= 12.5\ \text{A}$

(ii) The total current flowing through F_1 is $I_1 = I_2 + I_3 = 12.5\ \text{A} + 8.3\ \text{A}$
$= 20.8\ \text{A}$, which is more than 15 A.

(iii) Nothing happens to fuse F_2.
Fuse F_2 and F_3 are arranged in parallel, so even if fuse F_3 melts, it will not affect fuse F_2.

(c) Circuit breaker

3. (a) (i) A fuse

(ii) The fuse will melt and disconnect the circuit when the current flowing through it exceeds its rated value.

(b) (i) The earth pin is connected to the earth wire, which provides a low-resistance conducting path for the current to flow to earth should the metal tube becomes live.

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(ii) Cost of electricity

$= 0.5 \text{ kW} \times (\frac{1 \times 6}{60}) \text{ h} \times 25 \text{ cents}$

$= 1.25 \text{ cents}$

4. Wire: Live

Reason: When the switches or fuses are connected to the live wire, the current to the appliance could be disconnected when the switch is open or when the fuse melts in the event of a large current flow. This will protect the person touching the casing.

5. (a) (i) Resistance, $R = \frac{V}{I}$

$= \frac{11.90 \text{ V}}{0.70 \text{ A}}$

$= 17 \ \Omega$

(ii) The p.d. supplied to lamp 1 by the power supply is not big enough. Thus, lamp 1 is not able to produce a higher power, hence it only glows dimly.

(b) (i)

voltmeter reading / V	ammeter reading / A
11.5	**1.55**

(ii) Power, $P = VI$

$= 11.5 \text{ V} \times 1.55 \text{ A}$

$= 17.8 \text{ W}$ (3 sig. fig.)

(iii) Charge, $Q = It$

$= 1.55 \text{ A} \times 65 \text{ s}$

$= 101 \text{ C}$ (3 sig. fig.)

(c) The operating voltage of lamp 3 is 6 V. However, the voltage supplied by the power supply is 12 V. Therefore, when lamp 3 is connected to the circuit, it works under its maximum power and glows brightly. After a short time, the excessive voltage causes lamp 3 to blow and stop working.

6. (a) neutral wire; blue

(b) (i) Current, $I = \frac{P}{V}$

$= \frac{2600 \text{ W}}{240 \text{ V}}$

$= 10.8 \text{ A}$ (3 sig. fig.)

Fuse rating: 13 A

(ii) Current, $I = \frac{P}{V}$

$= \frac{100 \text{ W}}{240 \text{ V}}$

$= 0.417 \text{ A}$ (3 sig. fig.)

change: Replace the 13 A fuse with a 1 A fuse.

explanation: The operating current of the appliance is less than 1 A. A suitable fuse should have a fuse rating that is slightly higher than the operating current.

(c) (i)

use	average power used /kW	time in use /h	energy consumption /kWh
lighting	0.8	270	**(0.8 × 270 =) 216**
cooking	12.0	150	**(12.0 × 150 =) 1800**
other	2.0	400	**(2.0 × 400 =) 800**

(ii) Total cost

= (216 kWh + 1800 kWh + 800 kWh) × 19.5 cents

= 54 912 cents

= $549 (3 sig. fig.)

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N(A) LEVEL SCIENCE (PHYSICS) SEPTEMBER/OCTOBER 2020 EXAMINATION PAPER

Paper 1

1. **B**

Time is 1 minute 58 seconds = 60 s + 58 s
= 118 s

Must-Know Concept:
Reading of the time on the stopwatch

2. **C**

The acceleration of a free-falling object near to the Earth's surface is approximately 10 m/s^2.

Must-Know Concept:
Recall that the acceleration of free fall is 10 m/s^2 and the gravitational field strength is 10 N/kg.

3. **B**

Resultant force = ma
= 4 kg × 2 m/s^2
= 8 N to the right

Y will be a larger force such that
force Y – force X = 8N
Hence, 12 N – 4 N = 8 N

Must-Know Concept:
Calculation of resultant force = mass × acceleration and the calculation of resultant force given two forces acting in opposite directions

4. **C**

Inertia refers to the reluctance of an object to change its motion when it is at rest or when it is in motion. Mass affects the amount of inertia of the object.

Must-Know Concept:
Inertia means that an object at rest tends to be at rest or an object in motion tends to be in motion.

5. **B**

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Since all the objects have the same mass, the object with the smallest volume will have the highest density.

Must-Know Concept:
$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

6. **A**

For the beam to be at equilibrium, total clockwise moments = total anti-clockwise moments.

Anticlockwise moments = 10 N (0.2 m)
= 2.0 Nm

Clockwise moments = 20 N (0.1 m)
= 2.0 Nm

Must-Know Concept:
Sum of anticlockwise moments = sum of clockwise moments (Applying Principle of Moments)

7. **C**

For an object to be just at rest without toppling, the weight must be acting along the tipping edge.

Must-Know Concept:
When the weight acts downwards
- through the base of the object, it provides a restoring moment;
- through the sides of the object, it provides a toppling moment;
- through the edge of the base of the object, it is just at rest without toppling.

8. **D**

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

To increase the pressure on the ground, the area in contact with the ground should be smaller. Hence, when the man lifts one foot off the ground, the total area in contact with the ground will be reduced and the pressure exerted will be higher.

Must-Know Concept:
$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

9. **B**

Work done = Force applied × Distance travelled
100 J = 80 N × Distance travelled

$$\text{Distance moved} = \frac{100\text{ J}}{80\text{ N}}$$
= 1.25 m

Must-Know Concept:
Work Done = Force applied × Distance travelled

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10. **C**
Gas particles are moving at high speeds, are very far apart and moving in random directions.

Must-Know Concept:
Motion and arrangement of solid, liquid and gas particles

11. **A**
Heat is transmitted from a region of higher thermal energy to a region of lower thermal energy, radiating outwards from the heat source in a circular manner. Correspondingly the kinetic energy of regions that are hotter will be higher.

Must-Know Concept:
Heat is transferred in a radial manner, radiating outwards from the heat source and that the kinetic energy of the substance is related to the temperature.

12. **C**
Boiling occurs throughout the liquid and it forms bubbles as the liquid turns into gas. Evaporation occurs at any temperature above melting point when the substance is fully liquid and some liquid particles have enough kinetic energy to become gas.
The rate of evaporation is affected by the surface area of the liquid exposed. A larger surface area will mean a higher rate of evaporation. Temperature also affects the rate of evaporation as a higher temperature means that more liquid particles are of higher kinetic energy and will become gas more easily.

Must-Know Concept:
Difference between boiling and evaporation and the factors that affect evaporation

13. **D**
Sound is a longitudinal wave and longitudinal waves consist of compressions and rarefactions. Sound cannot travel in vacuum and needs a medium for transmission.
Light is a transverse wave and transverse waves consist of crest and troughs. Light is able to travel through vacuum.

Must-Know Concept:
Difference between transverse and longitudinal waves; examples of transverse and longitudinal waves

14. **C**
X-rays are used in the detection of broken bones.
Gamma rays are used in the treatment of cancer.
Ultraviolet is used in the sterilisation of equipment.

Must-Know Concept:
Uses of different components of the electromagnetic spectrum

15. **B**
The guitar is louder and lower in pitch. A louder sound has a larger amplitude and a lower pitch has a lower or smaller value for frequency.

Must-Know Concept:
Amplitude of the sound affects the loudness and frequency of the sound affects the pitch.

16. **B**
Electrons have a negative charge and the unit for charge is coulomb.

Must-Know Concept:
Charge on an electron and the unit for charge

17. **A**
Conventional current flows from the positive terminal of the battery to the negative terminal of the battery; electron flow's direction is opposite to conventional current flow.

Must-Know Concept:
Current flow is opposite in direction from electron flow.

18. **A**
A is a rheostat or a variable resistor. B is a fixed resistor while C is a fuse and D is a light bulb. Connecting a rheostat will allow the potential difference across the motor to change—a larger rheostat resistance will mean that the potential difference across the motor will be less; while a smaller rheostat resistance will allow the potential difference across the motor to be more.

Must-Know Concept:
Symbols for the various electrical components and the use of a rheostat as a potential divider

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19. **C**

Fuse should be installed in the live wires of the electrical circuit so that when there is a fault, and there is a high current flow, the fuse will blow and disconnect the appliances. This helps to protect the user.

Must-Know Concept:
Location of the fuse in an electrical circuit

20. **B**

For an appliance that has double insulation, the earth wire (the wiring at the top) is not required but the live wire and the neutral wire should still be connected as usual so that the appliance is able to function. Live wire (brown) should be connected to the fuse while the neutral wire (blue) should be connected to the opposite side of the live wire.

Must-Know Concept:
Meaning of double insulation and the internal wiring of an electrical plug

Paper 2

Section A

1. (a)

unit	symbol	multiple of the SI unit (J)
joule	J	1
kilojoule	kJ	**1000**
gigajoule	**GJ**	1 000 000 000
millijoule	mJ	0.001

2. (a) A wavefront joins points that are oscillating in phase. All crests are moving in phase and hence all crests are also a wavefront.

(b) 6 wavelengths have a length of 18 cm.
Each wavelength is 3 cm.

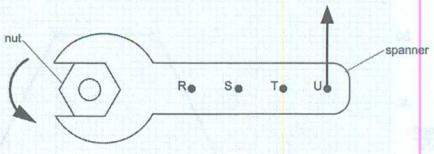
(c) 6 seconds results in 6 waves being produced.
1 wave is produced in 1 second, hence frequency is 1 Hz.

(d) Speed of the wave $= \frac{\text{Distance}}{\text{Time}}$

$= \frac{18 \text{ cm}}{6 \text{ s}}$

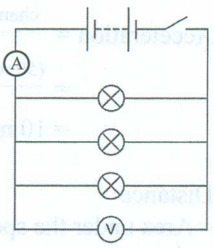
$= 3 \text{ cm/s}$

3. (a)



(b) At position U, the distance from the force to the turning nut is the greatest.
Since turning effect = Force × Perpendicular distance,
a larger distance from the turning nut will mean that the force required will then be the smallest.

4. (a)



Position of the ammeter can be anywhere along the main wire.

(b) (i) Current = 3.75 A
Voltage = 5.7 V

(ii) Effective resistance of the 3 lamps

$= \frac{5.7 \text{ V}}{3.75 \text{ A}}$

$= 1.52 \ \Omega$

(iii) Effective resistance

$= \frac{1}{1.52} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R}$

$\frac{1}{1.52} = \frac{3}{R}$

$R = 4.56 \ \Omega$

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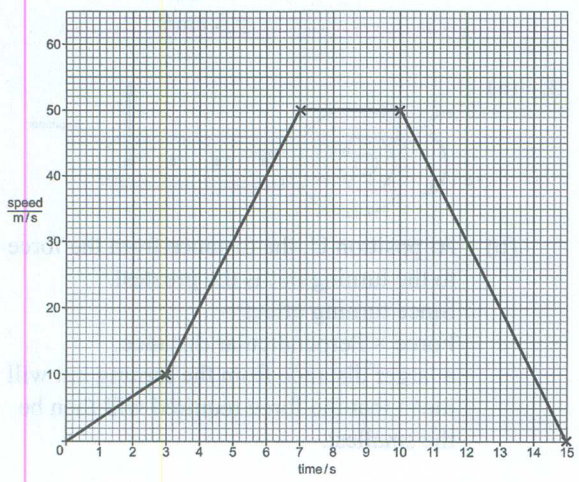
Section B

5. (a) (i), (ii)



(b) (i) $\text{Acceleration} = \dfrac{\text{change in speed}}{\text{time}}$

$= \dfrac{(50\text{ m/s} - 10\text{ m/s})}{4\text{ s}}$

$= 10\text{ m/s}^2$

(ii) Distance
= Area under the speed-time graph
$= \frac{1}{2}(10 + 50)(4) + 3(50)$
$= 270\text{ m}$

(c) Speed is a scalar quantity as it has a magnitude but no direction.

(d) The car initially has high kinetic energy. When brakes are applied, work is done against the turning wheels and energy is converted into thermal energy in the process as the kinetic energy is reduced.

6. (a) When the heater is switched on, heat is transferred from the hot heater to the cooler container by radiation. The container absorbs the infra-red radiation and gets heated up, and this in turn causes the gas inside the container to heat up as well. As the gas heats up, the molecules move faster and moves further apart, causing the volume to expand. The expanding gas pushes the drop of coloured water up the tube.

(b) container: G
explanation: Black is a good absorber of infra-red radiation.

(c) Energy consumed in 10 minutes
$= 1.8\text{ kW} \times \frac{10}{60}\text{ hours}$
$= 0.3\text{ kWh}$
Cost of energy $= 0.3\text{ kWh} \times 22\text{ cents}$
$= 6.6\text{ cents}$

(d) $\text{Current} = \dfrac{\text{Power}}{\text{Voltage}}$

$= \dfrac{1800\text{ W}}{240\text{ V}}$

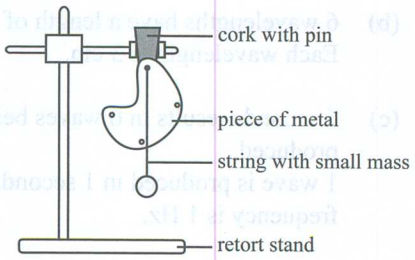
$= 7.5\text{ A}$

(e) fuse: 10 A
explanation: The selected fuse rating should be slightly higher than the normal operating current.

(f)

Time / minutes	Temperature / °C
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

7. (a) Set up the apparatus as shown in the diagram below.



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1. Insert the pin through one of the holes in the thin piece of metal. Ensure that the piece of metal is freely swinging. Allow the piece of metal to come to the rest position and is no longer oscillating.
2. Hang the string with a small mass on the pin and allow the string and mass to come to a rest as well.
3. Draw the line that the string makes across the piece of metal. This line will be the line of action of the weight of the thin piece of metal.
4. Repeat steps 1 to 3 using a different hole on the piece of metal.
5. The two drawn lines will intersect and the point of intersection will be position of the centre of gravity of the piece of metal.

(b) (i) Change in GPE
$= mgh$
$= 2 \text{ kg} \times 10 \text{ N/kg} \times 0.60 \text{ m}$
$= 12 \text{ J}$

(ii) KE the ball has
= all the GPE converted into KE of the ball just before it hits the bench
$= 12 \text{ J}$

(iii) Velocity of the ball is given by

$$\text{KE} = \frac{1}{2} mv^2$$

$$12 \text{ J} = \frac{1}{2}(2 \text{ kg})v^2$$

$$v = 3.46 \text{ m/s or } 3.5 \text{ m/s}$$

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Weightage of marks by topic

The table below shows the distribution of marks by topics for each paper. The highlighted figures denote the topics that are of significant weightage in the respective papers. The total marks for Paper 1 (P1) is 20, Paper 2 Section A (P2 A) is 14 and Paper 2 Section B (P2 B) is 16.

Topic	Weightage (by marks)																	
	2016			2017			2018			2019			2020			Average		
	P1	P2 A	P2 B	P1	P2 A	P2 B	P1	P2 A	P2 B	P1	P2 A	P2 B	P1	P2 A	P2 B	P1	P2 A	P2 B
Physical Quantities, Units and Measurement	5.0%	21.4%	–	5.0%	–	–	5.0%	–	–	5.0%	21.4%	–	5.0%	14.3%	6.3%	5.0%	11.4%	1.3%
Kinematics	5.0%	–	12.5%	–	–	31.3%	10.0%	28.6%	50.0%	5.0%	21.4%	–	5.0%	–	31.3%	5.0%	10.0%	25.1%
Dynamics	5.0%	–	25.0%	5.0%	–	–	–	–	–	10.0%	–	–	5.0%	–	–	5.0%	–	5.0%
Mass, Weight and Density	5.0%	–	–	10.0%	14.3%	18.8%	10.0%	–	–	5.0%	–	–	10.0%	–	–	8.0%	2.9%	3.8%
Turning Effect of Forces	10.0%	7.1%	–	15.0%	–	–	10.0%	–	–	10.0%	–	–	10.0%	14.3%	25%	11.0%	4.3%	5.0%
Pressure	5.0%	–	–	–	7.1%	–	5.0%	–	–	-	14.3%	–	5.0%	–	–	3.0%	4.3%	–
Energy, Work and Power	10.0%	–	12.5%	15.0%	–	50.0%	10.0%	–	–	10.0%	21.4%	18.8%	5.0%	–	37.5%	10.0%	4.3%	23.8%
Kinetic Model of Matter	5.0%	–	–	5.0%	–	–	5.0%	–	–	5.0%	7.1%	–	5.0%	–	–	5.0%	1.4%	–
Transfer of Thermal Energy	5.0%	–	50.0%	5.0%	28.6%	–	5.0%	–	12.5%	5.0%	–	31.3%	5.0%	–	31.3%	5.0%	5.7%	25.0%
Thermal Properties of Matter	5.0%	–	–	5.0%	–	–	5.0%	14.3%	–	5.0%	14.3%	–	5.0%	–	–	5.0%	5.7%	–
General Wave Properties	5.0%	28.6%	–	5.0%	–	–	–	–	25.0%	5.0%	–	6.3%	5.0%	35.7%	–	4.0%	12.9%	6.3%
Electromagnetic Spectrum	5.0%	–	–	5.0%	–	–	5.0%	21.4%	–	5.0%	–	–	5.0%	–	–	5.0%	4.3%	–
Sound	5.0%	28.6%	–	5.0%	28.6%	–	5.0%	–	25.0%	5.0%	–	43.8%	5.0%	–	–	5.0%	11.4%	13.8%
Current Electricity	10.0%	14.3%	–	10.0%	–	50.0%	5.0%	21.4%	–	5.0%	–	18.6%	10.0%	7.1%	–	8.0%	8.6%	13.7%
D.C. Circuits	5.0%	–	–	5.0%	–	–	15.0%	–	–	10.0%	–	31.3%	5.0%	28.6%	–	8.0%	5.7%	6.3%
Practical Electricity	10.0%	–	50.0%	5.0%	21.4%	–	5.0%	14.3%	37.5%	10.0%	–	–	10.0%	–	18.8%	8.0%	7.1%	21.3%

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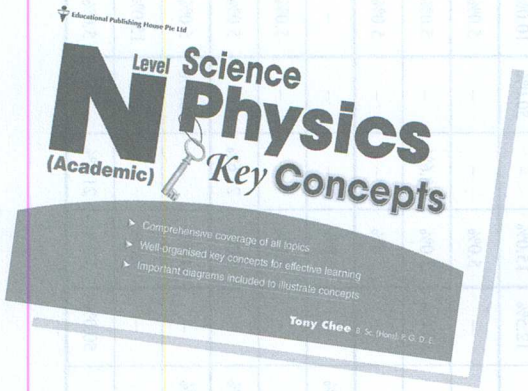

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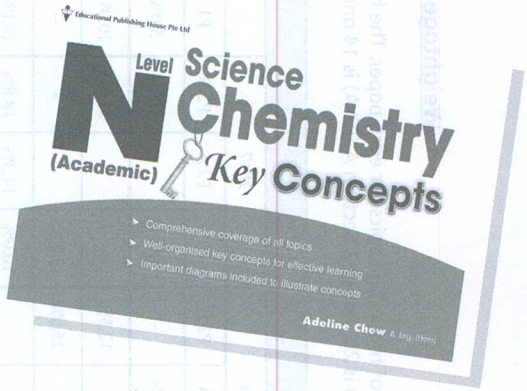

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