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MARK SCHEMES

Every examination has a *mark scheme*. **Mark schemes** are prepared by the **Chief Examiner** and considered, together with the relevant questions, by a panel of subject teachers. The *mark scheme* includes any amendments made at the *standardisation meeting* attended by all examiners and is the scheme which was used by them in the examination. The **standardisation meeting** ensures that the *mark scheme* covers the candidates' responses to questions and that every examiner understands and applies it in the **same correct way**.

EXAM REPORTS

Every examination has an *examiner's report*. The **Examiners' Report** may refer in general terms to statistical outcomes. Statistical information on candidates' performances in all examination components are provided when results are issued; as well as a review of the performance of candidates in the examinations and detailed analysis of the standards of answering, especially **erroneous understanding and wrong application of relevant concepts**.

CONTROVERSY

One would have assumed that the aim of the examination is to gauge and qualify candidates according to his/her standard of achievement and competence in the subject matter. Hence, after every examination, the *chief examiner* (internal or external) through the exam board will issue both the *mark scheme* and *exam report* to every school as a guide for teachers and future candidates helping them handle examinations more accurately.

Over the years, with the help of these relevant *mark schemes* and *examiner's reports*, candidates have steadily raised the quality and standard of answers.

The grades were concentrated at the top–end of the spectrum. This has caused problems to the exam boards trying to distinguish the better candidates from the poorer ones.

Instead of implementing a better qualification process, some exam boards chose the easy way out. These exam boards completely removed access to these important *mark schemes* and *examiner's reports* and classified these documents as "**confidential**", thus, running contrary to the *original spirit of education*.

We do not believe in this opacity. We believe in educating students through *total true knowledge*. Hence, in **all** our publications, we have, as far as practicable, included all relevant *mark schemes* and *exam reports* to as many question types as we could possibly get hold of.

We have a duty to ensure

> **"Knowledge is power. Total knowledge, acquired through accurate and completely true education, is absolute power."**

One simply must know how an examiner marks and what constitutes a complete and correct answer assuring ***full credit***.

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$$f(y) = f\left[f^{-1}(x)\right]$$

A property of function: *Any function of variable, x, being operated upon by its own inverse function will yield back the variable, x*:

$$\Rightarrow \quad f(y) = x$$

$$\Rightarrow \quad \frac{1}{y-1} = x \quad \Rightarrow \quad \frac{1}{x} = y - 1 \quad \Rightarrow \quad \frac{1}{x} + 1 = y = f^{-1}(x)$$

$\therefore$ *From* ❶, *the inverse function is*:

$f : x \mapsto \frac{1}{x} + 1$, $x \in \mathbb{R}$, $x \neq 0$. **(ans)**

❹ **Facts:**

Example

Posted on <stomp.com.sg> on 10 Nov 2009

MOE approved Physics textbook teaches my nephew the wrong thing.

A STOMPer's nephew came home crying after his GCE 'O' level Physics exam. He answered a question according to what he studied from the MOE approved textbook, only to find out later that it was wrong.

How can the MOE approved textbooks, which so many students use, carry such errors and ambiguities, questions this STOMPer.

Says this STOMPer:

"My nephew who sat for his GCE 'O' level exam came back crying and showed me his Physics Paper 1 (5058/01) in which Q19 says:

> What is the refractive index of a medium?
>
> A the ratio of the speed of light in air to the speed of light in the medium.
>
> B the ratio of the speed of light in the medium to the speed of light in air.
>
> C the ratio of the speed of light in the medium to the speed of light in vacuum.
>
> D the ratio of the speed of light in vacuum to the speed of light in the medium.

"According to the internet, which I have checked the answer is 'D'.

My nephew who wrote the answer as 'A' later consulted his teacher after the exam and was told that the answer is 'D'.

According to his textbook page 231 the authors say 'It has been proven that the refractive index is a ratio between the speed of light in air or vacuum and the speed of light in a medium'.

The cover of the school textbook titled GCE 'O' Level Physics matters by Charles Chew and Chow Siew Foong and there was a seal with the words 'Approved by Ministry of Education for use from 2007 - 2011'

This was the textbook used in many of our secondary schools and endorsed by the MOE.

If the textbook has errors or ambiguities why does MOE recommend that schools use this particular textbook?"

A *competent guide* would have explained that the determination of any physical standard, such as the refractive index, must be found based on invariant bench–mark(s). Air being

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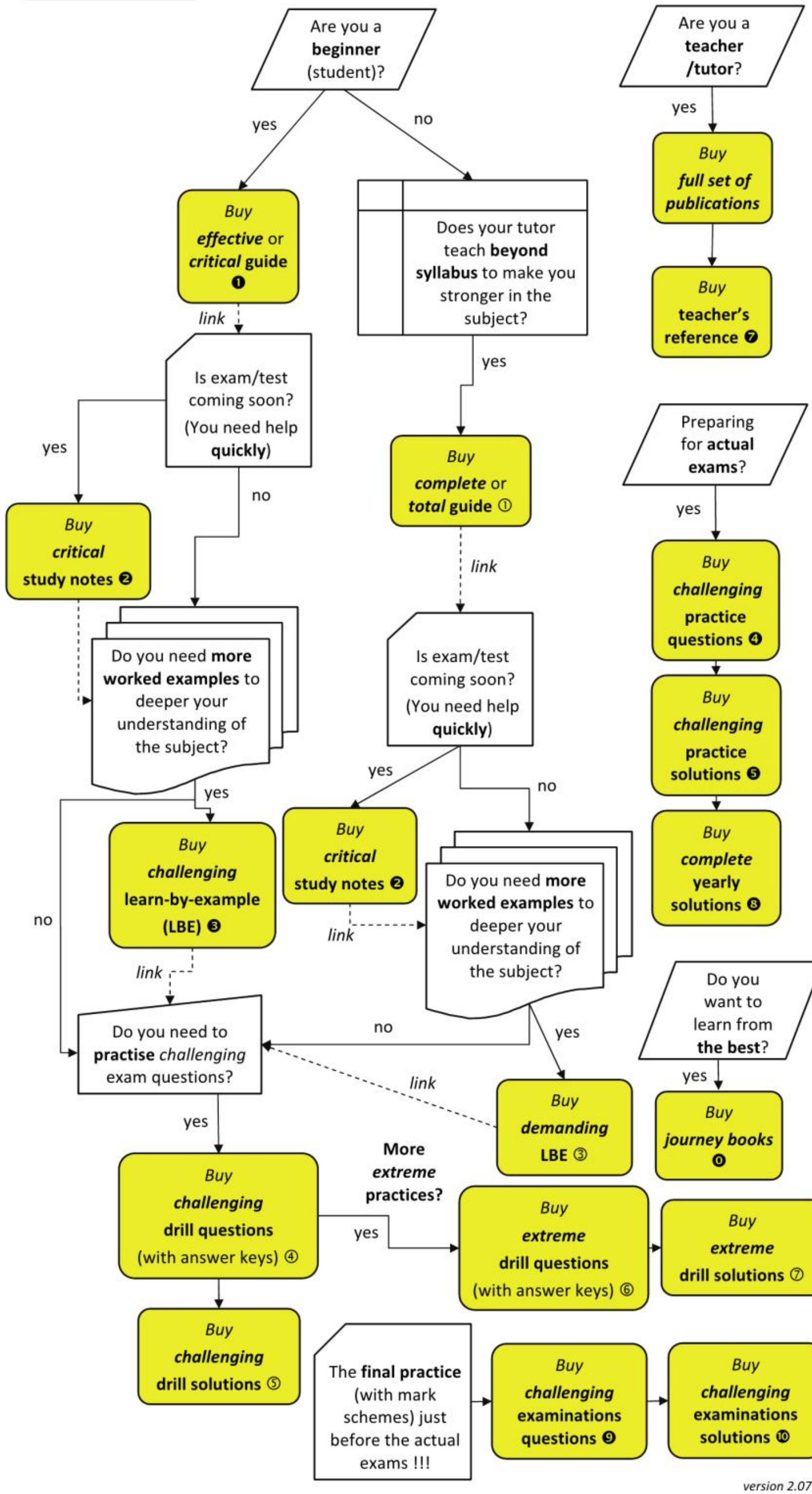
ROAD MAP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***demanding* LBE ③**	The MCQs / structured question-types were taken from actual exams worldwide. The deliberations were from easy to hard. (topical)	The MCQs / structured question-types were taken from actual exams worldwide. The deliberations were from easy to hard. (topical)
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1

GENERAL PHYSICS

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1.1.3 Prefixes

MCQs

1. Which of the following can 12 hours and 45 mins be written as?

(A) 12.45 hr

(B) 7.45×10^{2} min

(C) 4.59×10^{4} s

(D) 4.45×10^{7} ms

2. Which of the following is equivalent to 0.84 g cm^{-3}?

(A) 84 kg m^{-3}

(B) 8.4×10^{2} kg m^{-3}

(C) 8.4×10^{3} kg m^{-3}

(D) 8.4×10^{4} kg m^{-3}

Questions – 1.1.3

1. Fill in the blanks in the table below.

Name	Prefixes
deci	
centi	
	10^{-3}
	10^{-6}
nano	
	10^{-12}
kilo	
giga	

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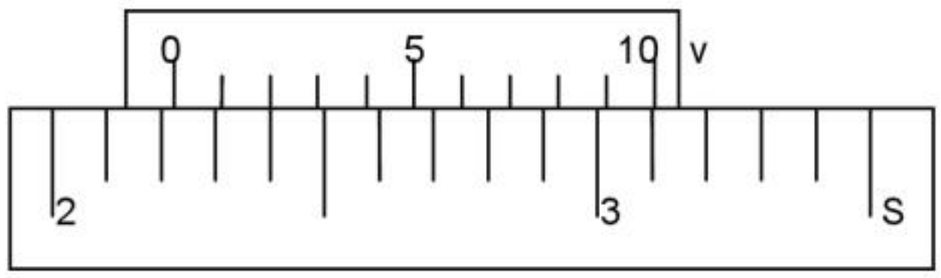
1.1.5 Length & time

MCQs

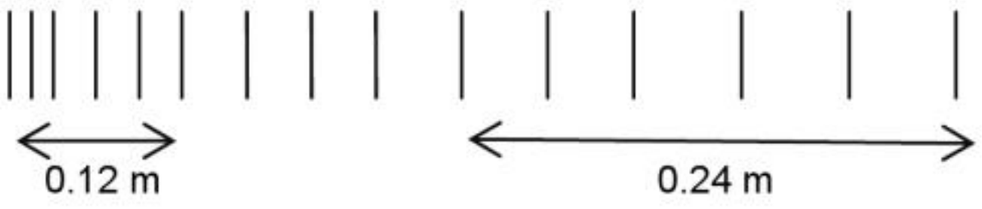
1. A vernier scale v is placed against a scale S. The vernier reading is



(A) 2.13 (B) 2.22

(C) 2.33 (D) 2.50

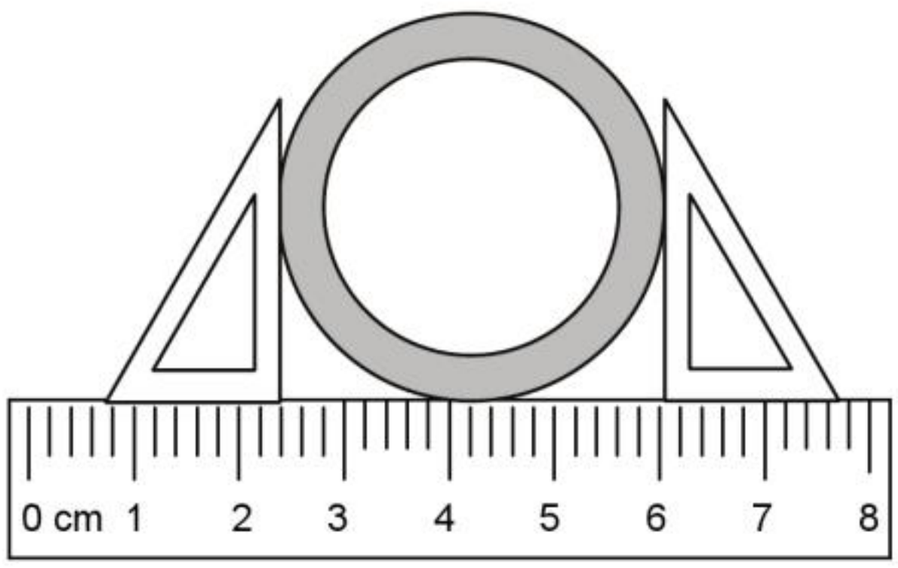
2. A trolley moves with an acceleration. The chart below records its motion by a ticker-tape timer of frequency 50 Hz. Find the acceleration of the trolley.



(A) 4 m s^{-2} (B) 5 m s^{-2}

(C) 6 m s^{-2} (D) 7 m s^{-2}

3. The diagram shows a thick-walled tube. The thickness of the wall is 3 mm.

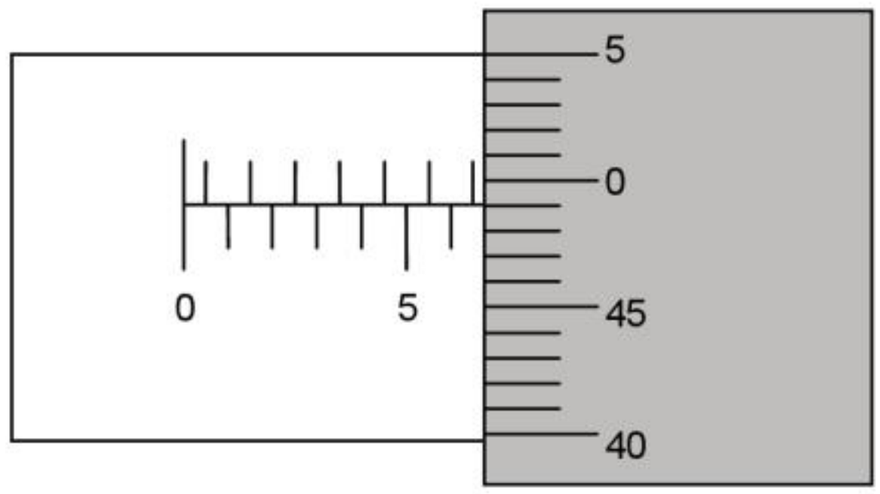


What is the internal diameter d of the tube?

(A) 2.8 cm (B) 3.0 cm

(C) 3.4 cm (D) 7.4 cm

4. The diagram shows part of a micrometer screw gauge.



What is the reading (in mm) shown?

(A) 5.39 (B) 5.49

(C) 5.99 (D) 6.99

5. A steel rule is used to measure the length of bar whose length is 8.4 cm. Repeated measurements give the following readings.

Length / cm	8.4	8.7	8.3	8.4	8.6

Are the readings accurate and precise to within 1 mm?

	Results are accurate to within 1 mm	*Results are precise to within 1 mm*
(A)	No	Yes
(B)	No	No
(C)	Yes	Yes
(D)	Yes	No

6. When comparing systematic errors and random errors, the following pairs of properties of errors in an experimental measurement may be contrasted.

P1: error can possibly be eliminated

P2: error cannot possibly be eliminated

Q1: error is of constant sign and magnitude

Q2: error is of varying sign and magnitude

R1: error will be reduced by averaging repeated measurements

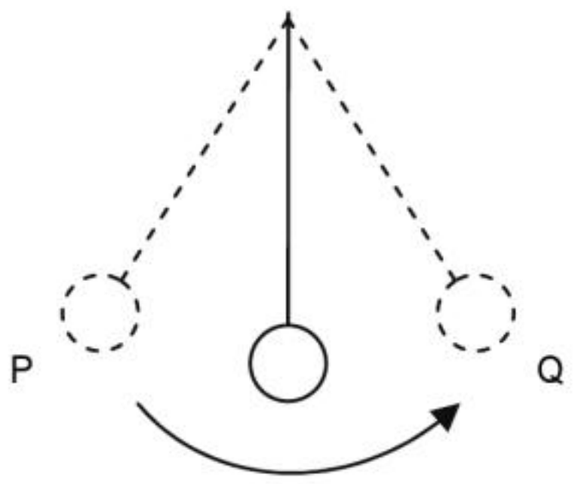
R2: error will not be reduced by averaging repeated measurements

Which properties apply to random errors?

(A) P1, Q1, R2 (B) P2, Q2, R1

(C) P1, Q2, R2 (D) P2. Q1, R1

7. The pendulum shown below takes 0.75 s to move from the point P to Q.



What is the period of the pendulum?

(A) 0.38 s (B) 1.5 s

(C) 0.75 s (D) 3.0 s

8. The periodic time of a simple pendulum can be significantly reduced by

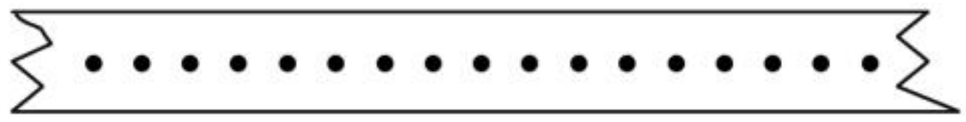
(A) increasing the mass of the pendulum.

(B) decreasing the mass of the pendulum.

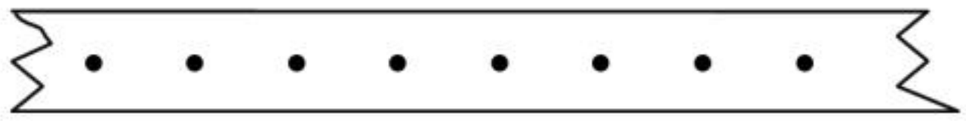
(C) decreasing the length of the pendulum.

(D) increasing the length of the pendulum.

9. The following ticker-tape is obtained with a trolley running along a runway.



With the same arrangement, which of the following change will NOT result in the tape below?



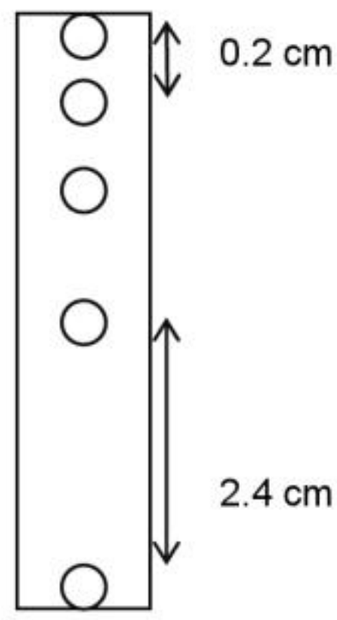
(A) Push the trolley harder to start with.

(B) Increase the slope of the runway.

(C) Decrease the frequency of the timer.

(D) Increase the speed of the trolley.

10. The stroboscopic plate is taken at a frequency of 20 Hz. What is the downward acceleration?



(A) 0.15 m s^{-2} (B) 2.93 m s^{-2}

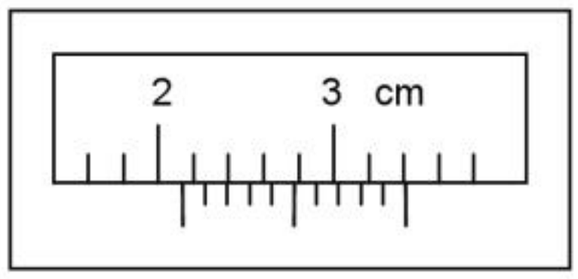
(C) 1.60 m s^{-2} (D) 3.20 m s^{-2}

11. A student had been asked to calculate the volume of a piece of wire, which is roughly 80 cm long and about 0.2 cm in diameter.

Which measuring instruments should the student use?

	length	*diameter*
(A)	metre rule	vernier calipers
(B)	metre rule	micrometer
(C)	micrometer	vernier calipers
(D)	vernier calipers	micrometer

12. The diagram shows the scale of a vernier caliper.

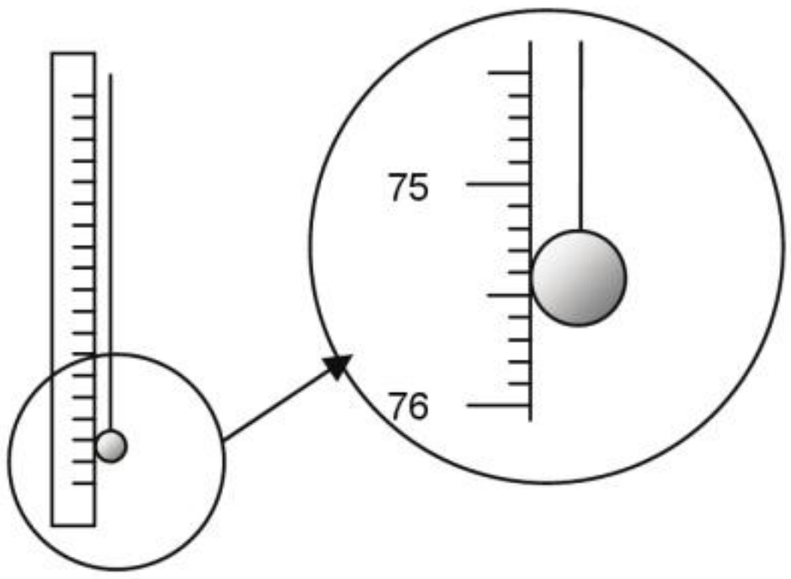


If the zero reading of this vernier caliper is + 0.03 cm, what is the correct reading of the measurement taken?

(A) 1.34 cm (B) 1.99 cm

(C) 2.02 cm (D) 2.05 cm

13. A student attempts to measure the length of a pendulum as shown in the diagram. What is the reading?



(A) 75.3 cm (B) 75.4 cm

(C) 76.5 cm (D) 76.6 cm

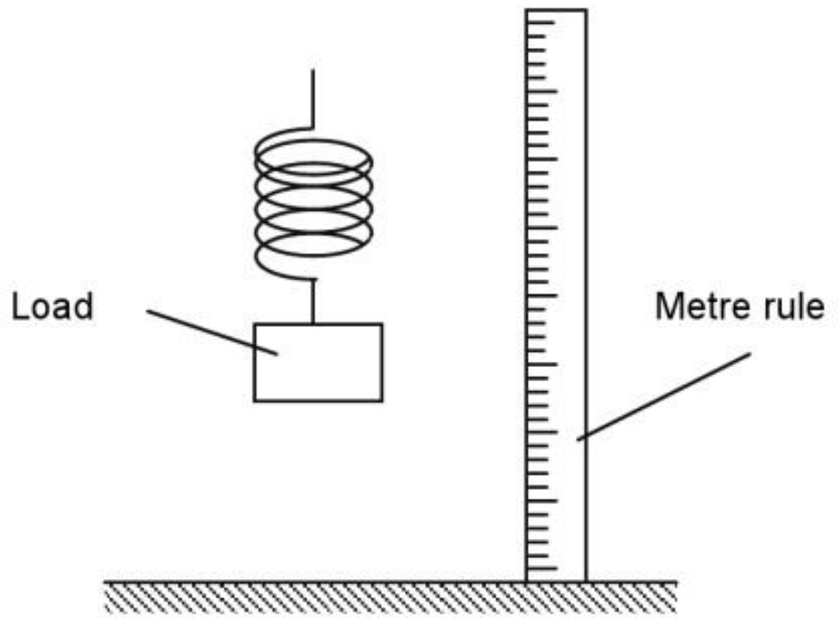
Questions – 1.1.5

1. (a) What is meant by

(i) a systematic error,

(ii) a random error?

(b) The spring constant of a spring may be determined by finding the extension of the spring and the load applied using the apparatus shown in the figure below.



(i) Give one example of a systematic error and one example of a random error which could occur in this experiment.

(ii) Readings of the position of the lower end of the spring are made using the metre rule. Suggest a method by which the error in these readings may be kept to a minimum using an optical pin.

(iii) If the extension of the spring is of the order of a few millimeters, comment on the reliability of the measurements.

Answer keys:

1.1.1

MCQs

1. A

Questions

1. $m\ s^{-1}$,
   $kg\ m\ s^{-2}$,
   $kg\ m^2\ s^{-3}$,
   $kg\ m^2\ s^{-2}$,
   $m^2\ s^{-2}\ K^{-1}$,
   $kg\ m^2\ s^{-2}$,
   $kg\ m^{-1}\ s^{-2}$,
   $kg\ m^2\ s^{-2}$

1.1.2

MCQs

1. A
2. C
3. C
4. C

Questions

1. (a)(i) kg, K, current, mol
   (b)(i) $kg^{-1}\ m^3\ s^{-2}$,
   $kg\ m^2\ s^{-1}$

1.1.3

MCQs

1. C
2. B

Questions

1. 10^{-1}, 10^{-2}, milli, micro, 10^{-9}, pico, 10^3, 10^9

1.1.4

MCQs

1. D
2. A
3. C
4. A
5. B
6. B

Questions

1. 1.98 kN
2. 310 km
3. (a) 6.12 units in the direction of 112.5° to the positive *x*-axis.
   (b) 14.8 units in the direction of 22.5° to the positive *x*-axis.
4. 9.54 units in the direction direction of 63° to the positive *x*-axis.
5. 196 cm in the direction of 345° to the positive *x*-axis.
6. (a) 185 N in the direction of 77.8° to the positive *x*-axis.
   (b) 185 N in the direction of 258° to the positive *x*-axis

1.1.5

MCQs

1. B
2. D
3. B
4. D
5. D
6. B
7. B
8. C
9. B
10. B
11. B
12. B
13. B

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1.2 SPEED, VELOCITY & ACCELERATION

1.2.1 Speed, velocity & acceleration

1.2.2 Graphical analysis of motion

1.2.3 Free-fall

1.2.4* Effect of air resistance

Learning Outcomes

Candidates should be able to:

Core

- Define speed and calculate speed from total time / total distance
- Plot and interpret a speed / time graph or a distance / time graph
- Recognise from the shape of a speed / time graph when a body is
  - at rest
  - moving with constant speed
  - moving with changing speed
- Calculate the area under a speed / time graph to work out the distance travelled for motion with constant acceleration
- Demonstrate some understanding that acceleration is related to changing speed

Supplement

- Distinguish between speed and velocity
- Recognise linear motion for which the acceleration is constant and calculate the acceleration
- Recognise motion for which the acceleration is not constant
- State that the acceleration of free fall for a body near to the Earth is constant
- Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity)

* - additional topic

Asterisks (#) placed alongside learning outcomes indicate areas of the syllabus where it is anticipated that teachers might use applications of information technology (IT), as appropriate. It should be appreciated that the list is not exhaustive.

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3. An experiment rocket model of mass 0.05 kg was launched vertically into the air with a propelling force of 4.5 N. The air resistance is assumed to be negligible. The rocket carries propellant only enough for 1.5 s of flight. The rocket then crashed to the ground after some time.

(a) State the weight of the rocket model.

(b) Calculate the acceleration of the rocket, which is assumed to be uniform, during the first 1.5 s of flight.

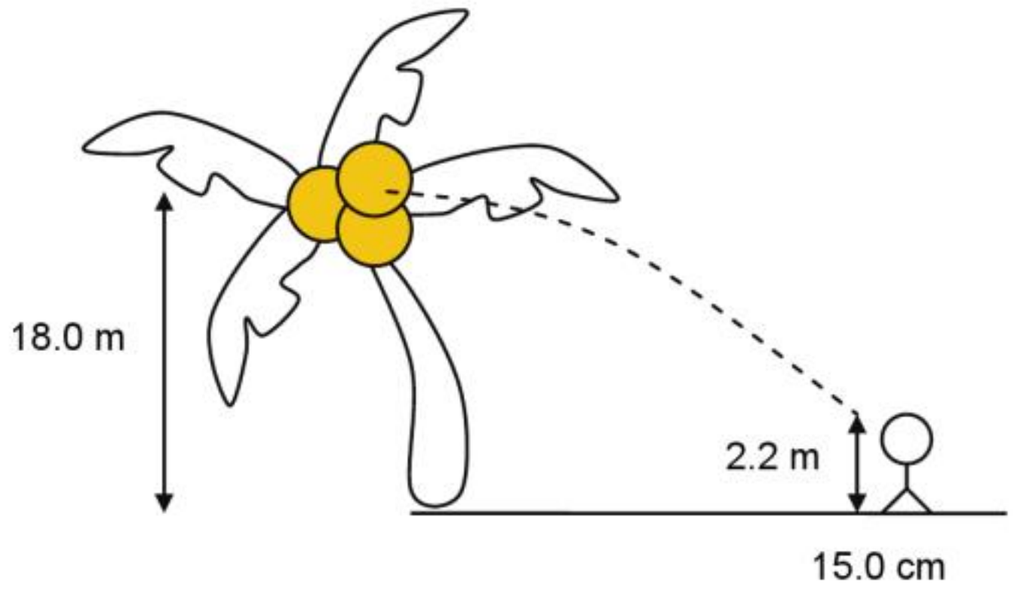
(c) What was the maximum velocity of the rocket?

(d) What was the acceleration of the rocket after 1.5 s of flight?

(e) Draw a clearly labeled velocity-time graph for the whole flight of the rocket from its take-off to its crashing to the ground.

(f) Below the graph you have drawn in (e), draw the corresponding distance-time graph for the same duration of flight.

4. Tarzan wanted to get a coconut from a coconut tree. As he was too hungry and weak to climb up the tree, he decided to throw a stone at the coconut to knock it down.



The coconut was 18.0 m above the ground. Tarzan found some stones to use as projectiles to knock the coconut off the tree.

His plan was to throw a stone such that it would hit the coconut horizontally because he thought it would be easiest to break the coconut off its stalk using a horizontal force. He threw a stone with an initial velocity of 20 ms^{-1} at and angle of 45° to the horizontal.

(a) Describe the shape of the trajectory of the stone.

(b) Given that his hand was 2.2 m above the ground when the stone was released, show that the stone was unable to reach the coconut, regardless of where he stood.

(c) He decided to try again. After some thought, he reckoned that he had to throw the stone at a larger angle ϑ to the horizontal in order to hit the coconut.

(i) Find the value of ϑ at which the stone had to be projected so that it would hit the coconut horizontally. Assume that the stone was again projected at 20 ms^{-1}.

(ii) Find the time taken for the stone to reach its maximum height at this angle of projection.

(iii) Hence, calculate the distance from the coconut tree at which he should stand t throw the stone so that it could hit the coconut.

5. A car is being driven in foggy conditions where visibility is poor. The maximum retardation of the car is 7.5 ms^{-2}.

(a) Find the maximum speed the car can travel if it is to stop in a distance of 30 m.

(b) While driving at 22 ms^{-1} the driver suddenly sees a stationary car 30 m ahead. It takes the driver 0.40 s to react.

(i) Calculate the speed at which the car will hit the stationary car.

(ii) During impact, a piece of broken glass was flung forward with a speed of 15 ms^{-1} and at an angle of 30°to the horizontal. The values are given with respect to a stationary observer on the ground.

Find the time taken and the horizontal distance traveled by the broken glass before it hits the ground, given that it originates from a height of 0.90 m.

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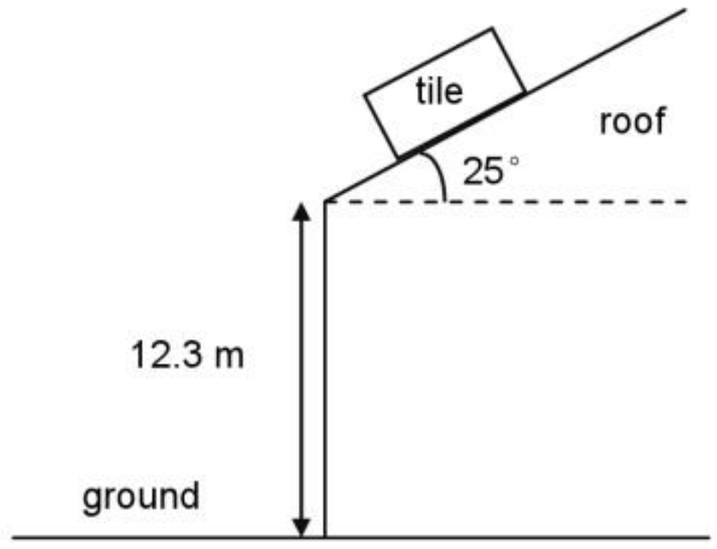


(i) Determine the speed of the tile just as it leaves the roof.

(ii) Determine how long it takes to hit the ground after leaving the roof.

(iii) Determine the horizontal distance from the edge of the roof at which the tile lands.

(c) Car A stops at a red light. As the light turns green, it accelerates forward at 2.4 m s^{-2}. At the exact same instant, car B passes by traveling at a constant speed of 60 km h^{-1}.

(i) Determine the time taken for the cars to meet again.

(ii) How far down the road will they meet?

(iii) Sketch the displacement-time graph for each car on the same axes, indicating the values you have obtained in (i) and (ii).

(iv) What was the average speed of car A for this time interval?

(v) Compare your answer in (iv) with the speed of car B and explain the result.

5. [Take upwards as positive for this question and follow initial conditions (t = 0 s, y_0 = 0 m and v_0 = 20.0 m s^{-1}) given]

A stone thrown from the roof of a building is given an initial velocity of 20.0 m s^{-1} straight upwards. The building is 50.0 m high and the stone just missed the roof on its way down. Determine

(a) the time needed for the stone to reach the maximum height.

(b) the maximum height from the roof top.

(c) the time needed for the stone to return to the top of the building.

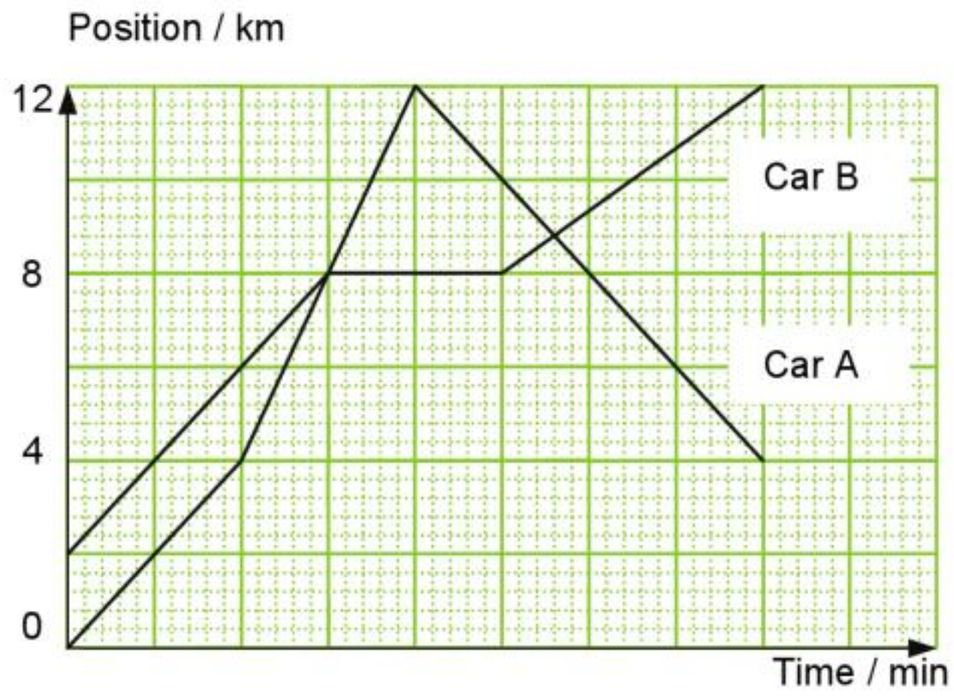
(d) the velocity of the stone at this instant.

(e) the velocity and position of the stone from the roof top at t = 5.00 s.

(f) the time needed for the stone to reach the bottom of the building and the velocity just before it hits the ground.

(g) Sketch the velocity-time graph for the motion of the stone from the start till it hits the ground.

6. The figure below shows positions of two cars A and B relative to a starting point with time.



(a) At what time do A and B have the same speed? Explain your answer.

(b) At what time does A first pass B?

(c) Sketch the corresponding speed-time graph of car A in the first 16 min.

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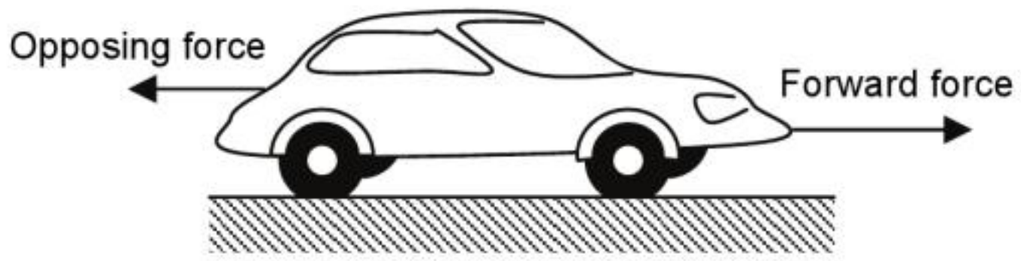
2. The figure below shows a car of mass 1250 kg moving along a straight, level road. The engine enables a forward force of 5500 N to act on the car. An opposing force, comprising air resistance and frictional forces, of 3000 N also act against the car.



(a) Calculate the acceleration of the car.

(b) As the car goes faster with the same forward force, it undergoes decreasing acceleration. Explain why this happens.

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1.3.2 Gravitational field & field strength

MCQs

1. An astronaut lands on a planet where the acceleration of free-fall at its surface is greater than that on Earth. Which one of the following will be the same as on Earth?

(A) The period of oscillation of a simple pendulum.

(B) The weight of the astronaut as measured by a swinging balance.

(C) The easiness in changing the motion of a swinging can of sand.

(D) The height reached by the astronaut when he jumps with the same initial velocity.

2. An astronaut's boots weigh 100 N on Earth where the acceleration of free-fall is 10 m s^{-2}.

How much will they weigh on Mars where the acceleration of free fall is 4 m s^{-2}.

(A) 25 N (B) 40 N

(C) 45 N (D) 53.3 N

3. Two rubber balls of the same size are both dropped on the Earth and on the Moon.

One ball is solid, and one is hollow. The approximate gravitational field strength on the Earth is 10 N kg^{-1} and on the Moon is 1.7 N kg^{-1}.

Which ball has the greatest force acting on it?

	Type of ball	*Where it's dropped*
(A)	hollow	on the Earth
(B)	hollow	on the Moon
(C)	solid	on the Earth
(D)	solid	on the Moon

Answer keys:

1.3.1

MCQs

1. B
2. D
3. C
4. D

1.3.2

MCQs

1. C
2. B
3. C

1.4
DENSITY

1.4.1 Density

Learning Outcomes

Candidates should be able to:

Core

- Describe an experiment to determine the density of a liquid and of a regularly shaped solid and make the necessary calculation

Supplement

- Describe the determination of the density of an irregularly shaped solid by the method of displacement, and make the necessary calculation

* - additional topic

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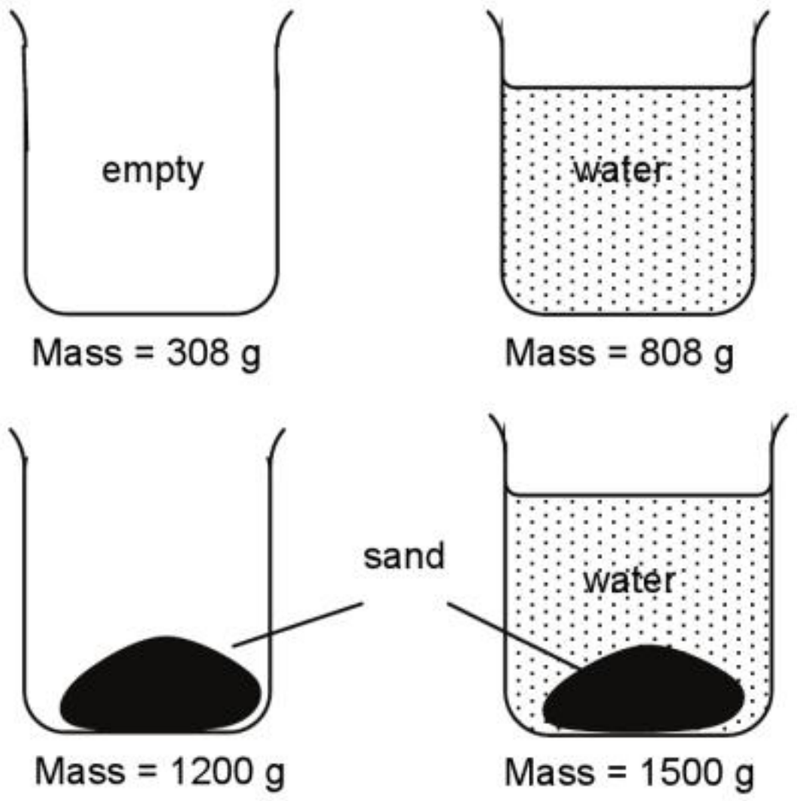
6. In an experiment to determine the density of sand, the measurements as shown below are obtained. If the density of water is 1.00 g cm^{-3}, what is the density of the sand?



(A) 2.22 g cm^{-3} (B) 2.47 g cm^{-3}

(C) 3.13 g cm^{-3} (D) 4.46 g cm^{-3}

7. Ten identical steel balls were immersed in a measuring cylinder containing 20 cm^3 of water. The reading of the water level rose to 50 cm^3. If the density of steel is 9.0 g cm^{-3}, what is the mass of one ball?

(A) 3 g (B) 27 g

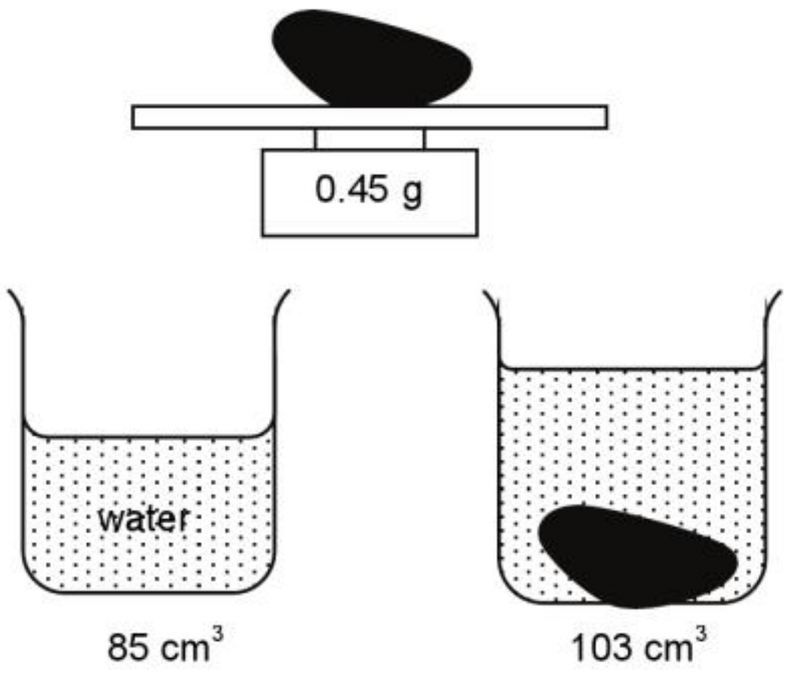
(C) 45 g (D) 270 g

8. The density of a gold bar is 19.0 g cm^{-3}. When a hole of volume 1.0 cm^3 is drilled into the bar, the density of the gold bar will be

(A) 18.0 g cm^{-3} (B) 19.0 g cm^{-3}

(C) 19.5 g cm^{-3} (D) 20.0 g cm^{-3}

9. The results obtained in an experiment to determine the density of a plastic material are illustrated in the figure below.



What is the density of the plastic material?

(A) 400 × 10^{-2} g cm^{-3}

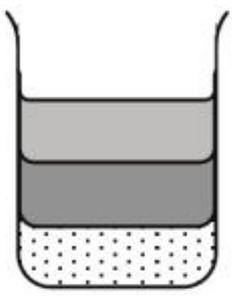
(B) 2.5 × 10^{-2} g cm^{-3}

(C) 5.3 × 10^{-2} g cm^{-3}

(D) 4.4 × 10^{-2} g cm^{-3}

10. The mass and the corresponding volume of three liquids X, Y and Z are recorded below.

Liquid	Mass	Volume
X	272 g	20 cm^3
Y	40 g	50 cm^3
Z	36 g	30 cm^3



The three liquids, which do not mix, are poured into a beaker as shown in the figure above. Starting from the top, the liquids will be in the order

(A) YZX (B) XYZ

(C) YXZ (D) XZY

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1.5 FORCES

1.5 (a) Effects of forces

1.5 (b) Turning effect

1.5 (c) Conditions for equilibrium

1.5 (d) Centre of mass

1.5 (e) Scalars and vectors

Learning Outcomes

Candidates should be able to:

1.5 (a) Effects of forces

Core

- State that a force may produce a change in size and shape of a body
- Plot extension/load graphs and describe the associated experimental procedure
- Describe the ways in which a force may change the motion of a body
- Find the resultant of two or more forces acting along the same line

Supplement

- Interpret extension/load graphs
- State Hooke's Law and recall and use the expression $F = kx$
- Recognise the significance of the term 'limit of proportionality' for an extension / load graph
- Recall and use the relation between force, mass and acceleration (including the direction)
- Describe qualitatively motion in a curved path due to a perpendicular force ($F = mv^2/r$ is not required)

1.5 (b) Turning effect

Core

- Describe the moment of a force as a measure of its turning effect and give everyday examples
- Describe qualitatively the balancing of a beam about a pivot

Supplement

- Perform and describe an experiment (involving vertical forces) to show that there is no net moment on a body in equilibrium
- • Apply the idea of opposing moments to simple systems in equilibrium

1.5 (c) Centre of mass

Core

- Perform and describe an experiment to determine the position of the centre of mass of a plane lamina

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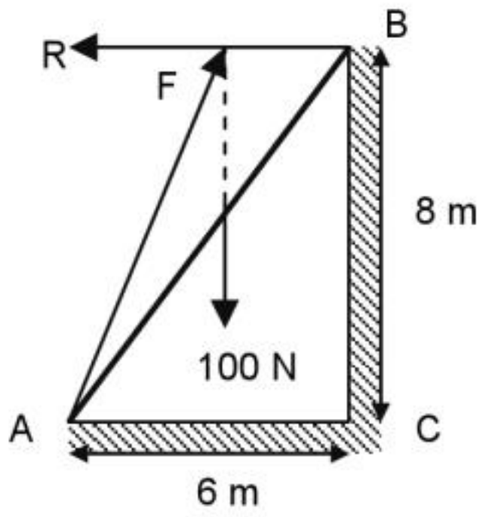
11. A uniform ladder of weight 100 N rests against a smooth wall at B and rough ground at A. R is the normal reaction force of the wall at B and F is the total force at the ground at A. The height BC is 8 m and AC is 6 m.

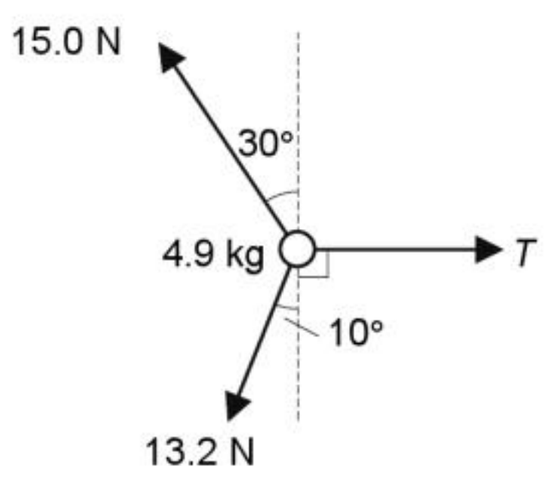


The value of F is

(A) 37.5 N (B) 50.0 N

(C) 107 N (D) 154 N

12. An object of mass 4.9 kg is on a horizontal frictionless surface. It is held in equilibrium by three horizontal strings with different tensions as shown below. The diagram is not drawn to scale.

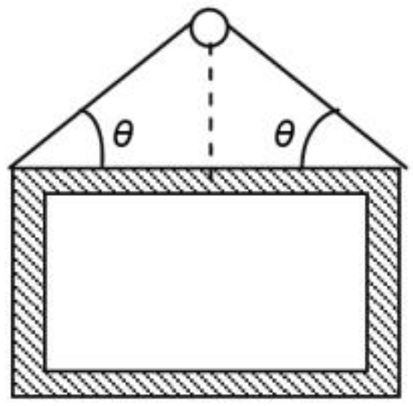


What is the value of the tension, T ?

(A) 5.2 N (B) 9.8 N

(C) 10.7 N (D) 26 N

13. A picture of mass 1.5 kg hangs on the wall freely as shown in the diagram below.



What is the minimum angle ϑ the cord can suspend without braking if the maximum tension that the cord can take is 20 N? (Take g as 10 m s^{-2})

(A) 22° (B) 41°

(C) 49° (D) 68°

14. Equilibrium exists in a system where three forces are acting concurrently on an object. If the system includes a 4.0 N force due north and a 3.0 N force due east, the third force must be

(A) 5.0 N northeast

(B) 5.0 N southwest

(C) 7.0 N northeast

(D) 7.0 N southwest

15. A tractor of mass 1500 kg pulls a trailer of mass 1500 kg. The total resistance to motion has a constant value of 5000 N. One quarter of this resistance acts on the trailer. When they are moving at a constant speed of 10 m s^{-1}, the force exerted on the tractor by the trailer is

(A) 0 N (B) 1250 N

(C) 3750 N (D) 4250 N

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meter. The values obtained are given in the table below.

tan ϑ	F / N
0.180	2
0.475	6
0.640	9
0.805	12
1.100	16

(i) Plot a graph of tan ϑ (y-axis) against F / N (x-axis). Draw the best fit line through your points.

(ii) Determine the gradient of your graph.

(c) (i) Use your graph to determine the angle ϑ when F = 10 N.

(ii) Explain with the aid of the figure above, how you would obtain accurate values of tan ϑ using a metre-rule.

6. A car of mass 500 kg is being towed along a straight road so that its velocity changes uniformly from 10 m s^{-1} to 20 m s^{-1} in a time of 8 seconds. During this time, the frictional resistance is constant and equals to 500 N.

(a) Calculate the acceleration of the car.

(b) What is the resultant force on the car during the 8 seconds?

(c) What is the force exerted on the car by the towing vehicle?

(d) When the speed of 20 m s^{-1} is reached, the towing force is reduced so that the car now moves with constant velocity.

(i) What is the resultant force on the car now?

(ii) What is the towing force?

7. A metal box, attached to a small parachute, is dropped from a helicopter.

(a) Explain in terms of forces acting, why its velocity increased immediately after being dropped.

(b) The total force opposing motion of the box and parachute at a particular instant during its fall is 30 N. The combined mass of the box and the parachute is 5.0 kg.

(i) Calculate the resultant downward force on the box and parachute. (Take g = 10 m s^{-1})

(ii) Briefly describe the motion of the box and parachute at this time.

(c) At the end of this fall, the parachute is caught on a tall tree. The box is then cut loose and falls from rest to the ground. The time of fall is 2.4 s. Calculate

(i) the velocity with which the box strikes the ground,

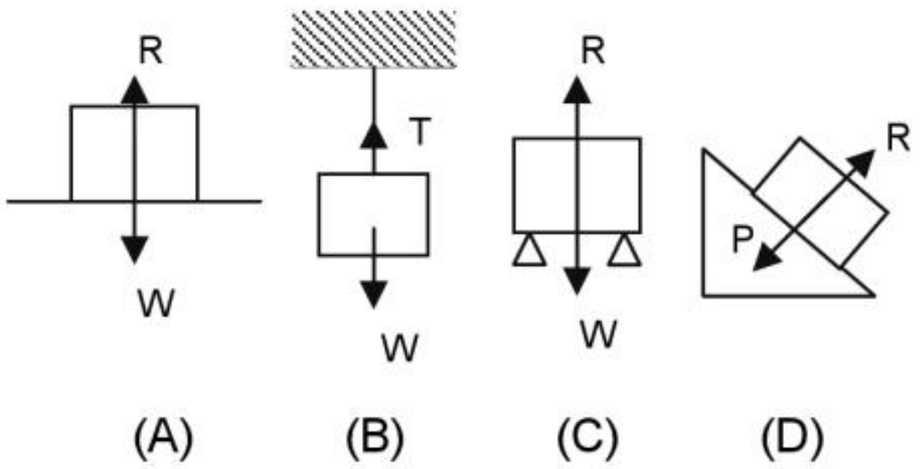
(ii) the average velocity during its fall,

(iii) the distance fallen. (Take g = 10 m s^{-1})

1.5(a).2 Free-body diagrams

MCQs

1. Which of the diagrams below shows a true action-reaction pair of forces?



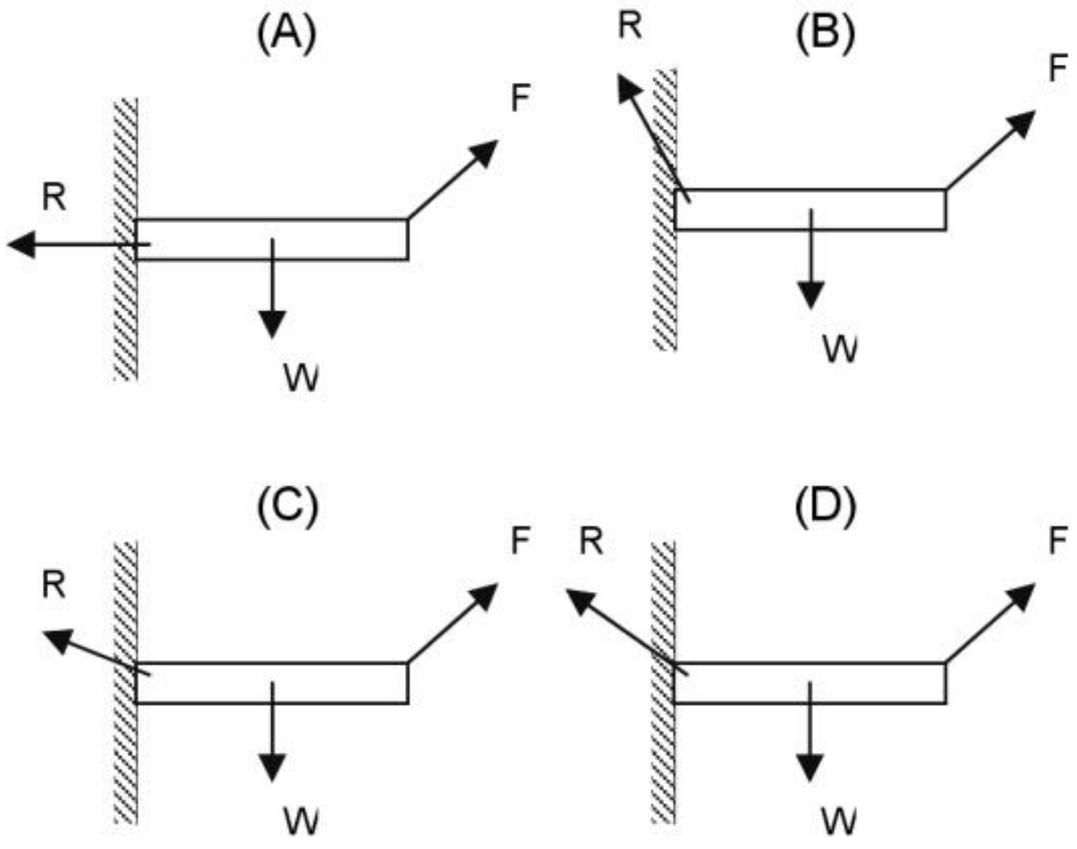
R - Reaction from the support

W - Weight of object

T - Tension in the string

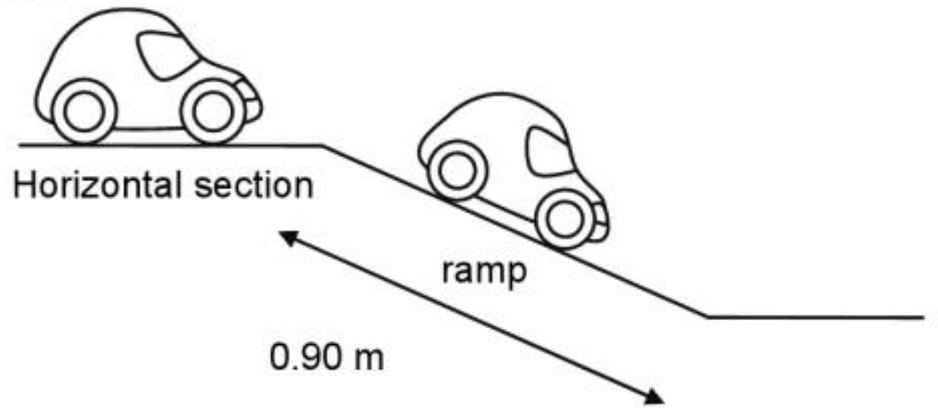
P - Force exerted by object onto support

2. A uniform rod of length L and weight W is hinged to the wall. A force F acts to support the rod in a horizontal position. Which diagram correctly shows the contact force R acting on the rod by the wall?



Questions – 1.5(a).2

1. A toy car is given a brief push which sends it along a horizontal section of a runway. The car moves down the ramp as shown in the figure below.



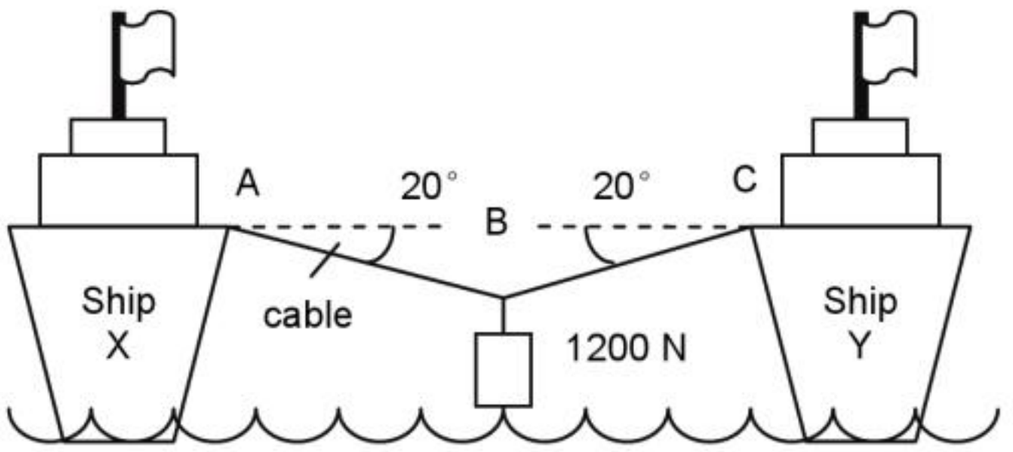
(a) Draw labeled arrows on the diagram to show the 3 forces acting on the car at A.

(b) The length of the ramp is 0.90 m and the average force of friction is 0.11 N. The car has 0.30 J of kinetic energy at the top of the ramp and loses 0.50 J of potential energy as it moves from the top to the bottom of the ramp.

(i) Calculate the work done by the car against friction as it moves down the ramp.

(ii) Calculate the kinetic energy of the car at the bottom of the ramp.

2. The figure below shows a ship-to-ship cable, ABC, used by the navy to transfer people and goods from one ship to another in dangerous conditions. Initially, the angle of declination of the cable from each ship is 20°when a 1200 N object is suspended at the mid-point.



(a) By using a suitable scale drawing or otherwise, find the forces present in the cables AB and BC.

(b) In very stormy weather, the sailors are always worried when they see the cable becoming horizontal because they know from experience that this can cause the cable to break. Such a broken cable often whips incredibly fast back to the decks of the ships causing severe injury or death.

Explain why an almost horizontal cable is very likely to break.

(c) The length of the smooth cable ABC is 60.0 m. A 100 kg object which is released at rest, travels from ship X to an identical ship Y.

(i) Calculate the weight of the 100 kg object.

(ii) Calculate the net work done against the force of gravity of the 100 kg object as it travels from ship X to ship Y.

(iii) Find the speed of the 100 kg object as it arrives at the midpoint of the cable.

3. When the head of a bungee jumper, of mass 70 kg, is 25 m from the surface of the water below, her velocity is 16 m s^{-1} downwards. The tension in the bungee cord is 1000 N. (Neglect air resistance)

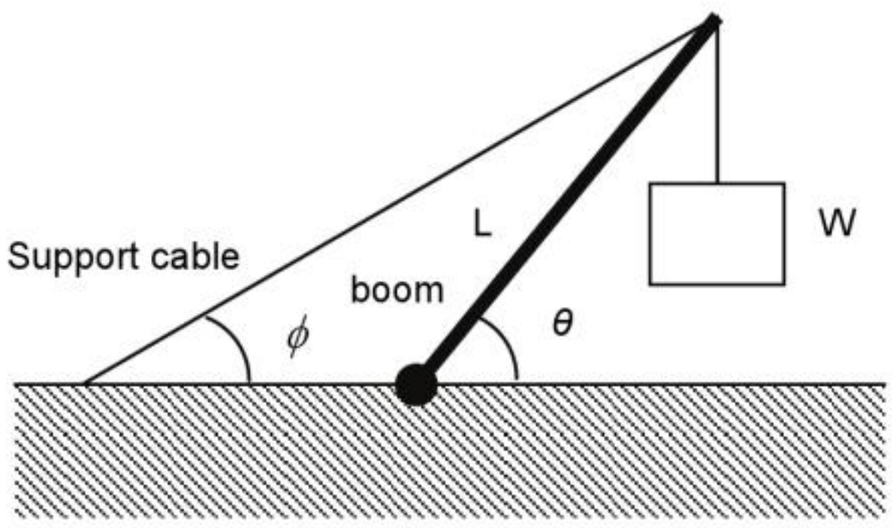
(a) Draw the forces acting on the bungee jumper at this instant.

(b) What is her acceleration at this instant?

(c) If her acceleration remains constant, determine if she will hit the water?

(d) In reality, the tension in the cord will keep on increasing as the bungee jumper continues to fall. What effect will this have on the acceleration obtained in (b)?

4. A crane is made from a uniform rigid boom of length L = 30 m and weight W = 400 N as shown in the figure below. The boom is supported at its lower end by a frictionless hinge on the ground. It upper end is attached to a support cable which is fastened on the ground behind the boom. Adjusting the length of the support cable adjusts the angle of the boom.



In a particular application, the crane is used to support a crate with weight W = 2.0 kN. The boom makes an angle ϑ = 45°with the horizontal and the support cable makes an angle ϑ = 30° with the horizontal.

(a) State the condition(s) for a body to be in static equilibrium.

(b) Draw a free body diagram for the boom, showing all the forces acting on it. Label each force clearly.

(c) Determine the tension in the support cable.

(d) Determine the magnitude of the force acting by the hinge on the boom.

(e) As mentioned, the support cable can lengthen or shorten to change the angle of the boom. Comment on the problem encountered when the boom is slowly lowered to become horizontal.

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Answer keys:

1.5(a).1

MCQs

1. A
2. A
3. B
4. D
5. A
6. B
7. D
8. C
9. B
10. C
11. C
12. B
13. A
14. B
15. B
16. A
17. B

Questions

1. 0.06 m s^{-2}
2. (a) 16500 N
   (b) 16500 N
   (c) 8675 N
3. 1400 N
5. (a)(i) 22.6 N
   45 ° clockwise from vertical thread
   (a)(ii) 22.6 N
   135 ° anticlockwise from vertical thread
6. (a) 1.25 m s^{-2}
   (b) 625 N
   (c) 1125 N
   (d)(i) 0 N
   (d)(ii) 500 N
7. (b)(i) 20 N
   (c)(i) 24 m s^{-1}
   (c)(ii) 12 m s^{-1}
   (c)(iii) 28.8 m

1.5(a).2

MCQs

1. D
2. D

Questions

1. (a)(i) 9.9×10^{-2} J
   (a)(ii) 0.70 J
2. (c)(i) 1000 N
   (c)(ii) 0 J
   (c)(iii) 14.3 m s^{-1}
3. (b) 4.48 m s^{-2} upwards
   (c) she will hit the Water
4. (c) 6011 N
   (d) 7.5 kN

1.5(a).3

MCQs

1. B
2. A

Questions

1. (c)(i) 4.0 N
   (c)(ii) 0.64 N
2. (a) 20 N
   (b) at t = 15 s, v = 30 m s^{-1},
   at t = 20 s,
   v = 20 m s^{-1}
   (d) 350 m

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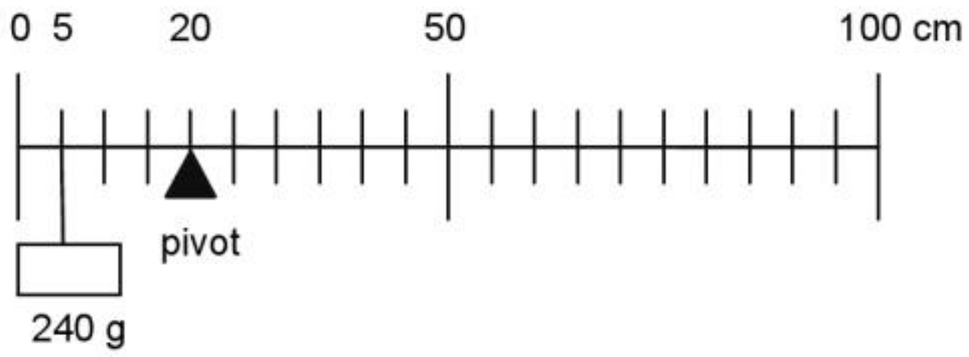
10. The diagram shows a uniform metre rule pivoted off-centre but kept at equilibrium by a suspended mass of 240 g.

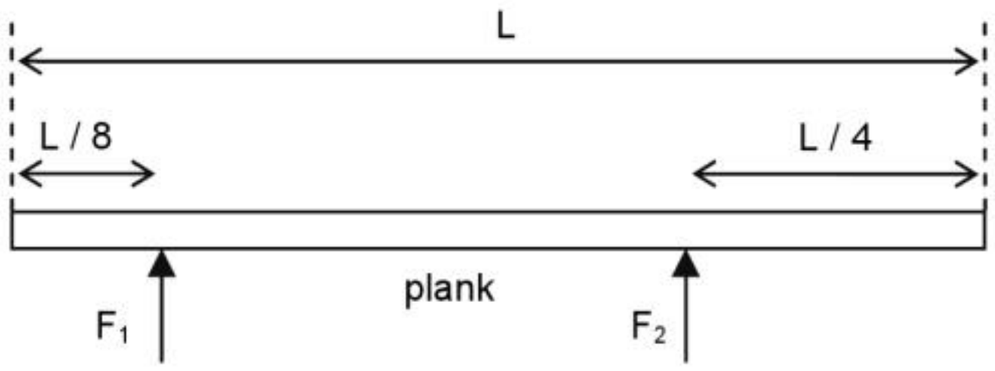


If the mass of the rule acts at the 50 cm mark, what is the mass of the rule?

(A) 12 g (B) 24 g

(C) 96 g (D) 120 g

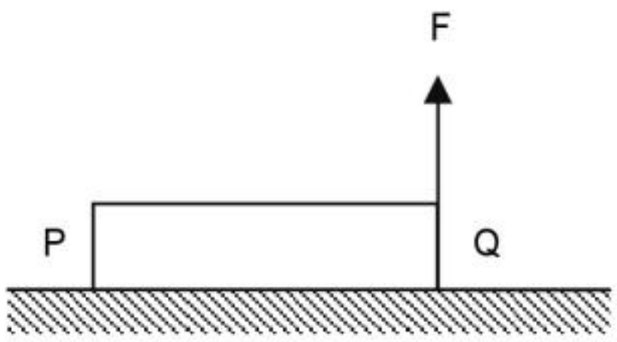
11. A heavy uniform plank of length L is supported by two forces F_1 and F_2 at points distance and $L/4$ from its ends as shown in the diagram below. What is the ratio of F_1 to F_2 ?



(A) 2 : 5 (B) 3 : 5

(C) 2 : 3 (D) 3 : 2

12. The diagram shows a uniform metal bar of length 4 m and mass 50 kg. A man pulls straight up with a force F at one end Q of the bar so that it pivots about the end P.



When the end Q just comes off the ground, what is the value of the force F?

(A) 25 N (B) 125 N

(C) 250 N (D) 500 N

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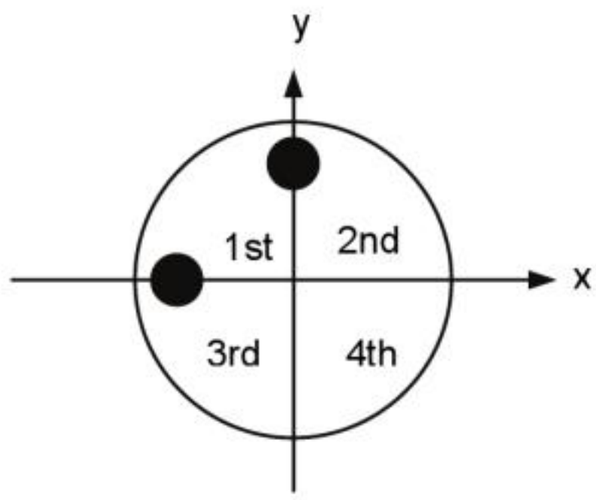
11. (a) Explain what is meant by the moment of a force, and show how it is calculated.

(b) Describe a simple experiment to verify the principle of moments, making clear what you would measure and how you would use your results to verify the principle.

1.5(c) Centre of mass

MCQs

1. The figure represents a uniform lamina with 2 shaded portions cut out. The center of gravity of the remaining portion is



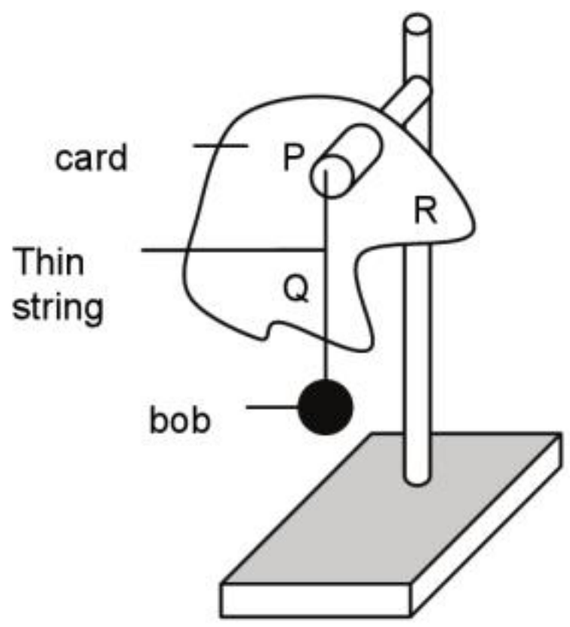
(A) in the 1st quadrant.

(B) in the 2nd quadrant.

(C) in the 4th quadrant.

(D) outside the lamina.

2. The diagram shows the first step in an experiment to determine the position of the centre of mass of a thin card.



What is the next step in this experiment?

(A) Find the mid-point of PQ.

(B) Hang the card from point R.

(C) Measure the mass of the card.

(D) Measure the thickness of the card.

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(c) What are the properties of plastic and lead which makes them suitable materials for use in a Tumbling Kelly.

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- Show an understanding that energy is released by nuclear fusion in the Sun
- Recall and use the equation:

  efficiency = (useful energy output / energy input) × 100%

1.6 (c) Work

Core

- Relate (without calculation) work done to the magnitude of a force and the distance moved

Supplement

- Describe energy changes in terms of work done
- Recall and use $\Delta W = Fd = \Delta E$

1.6 (d) Power

Core

- Relate (without calculation) power to work done and time taken, using appropriate examples

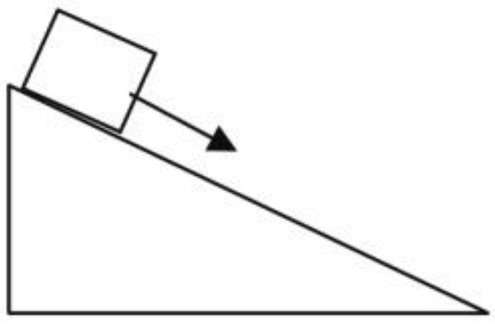
Supplement

- Recall and use the equation $P = E/t$ in simple systems

1.6a/b Energy

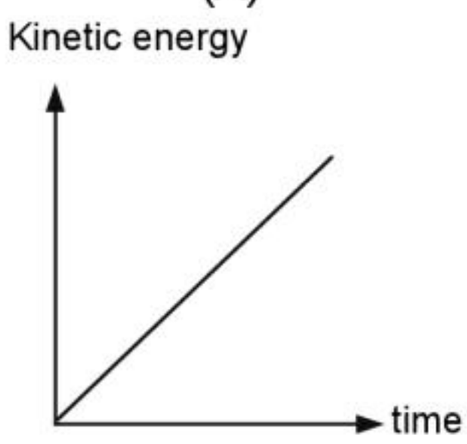
MCQs

1. A block slides from rest down a smooth inclined plane as shown in the diagram.

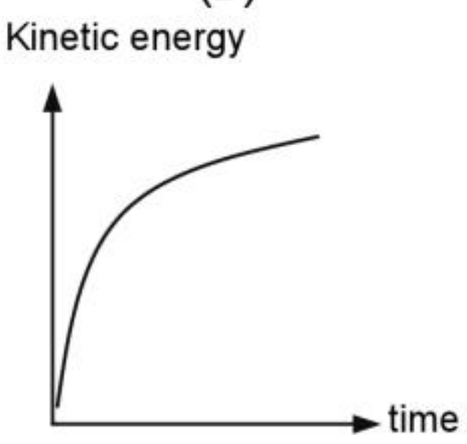


Which one of the following graphs correctly describes its variation of kinetic energy with time?

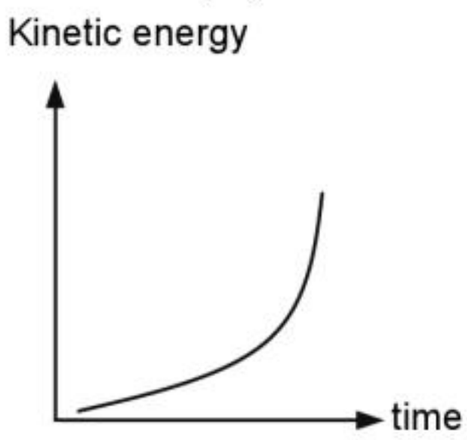
(A)



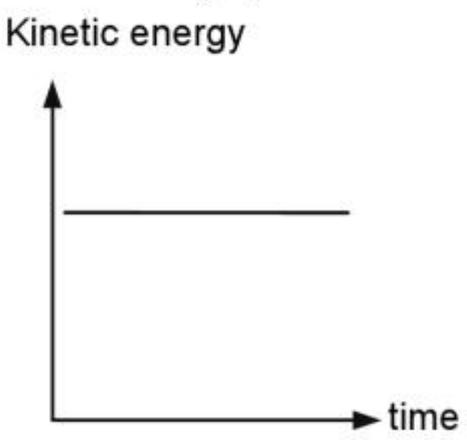
(B)



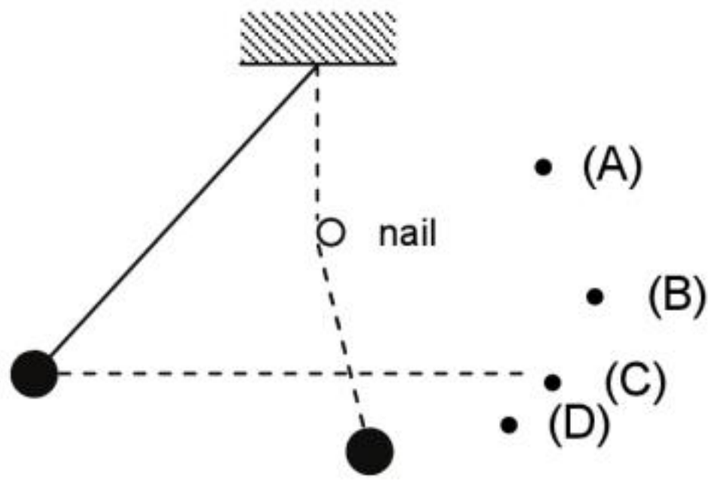
(C)



(D)

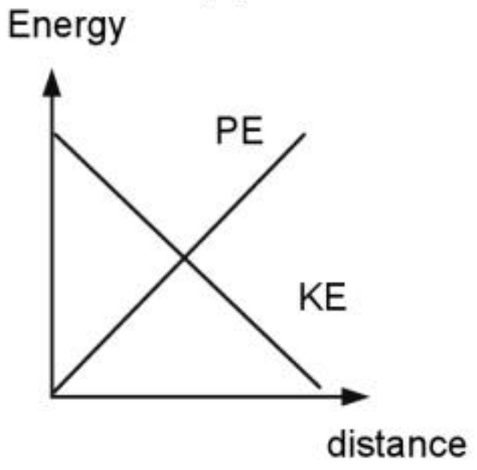


2. A pendulum bob, swinging down swiftly is obstructed by a nail. Neglecting friction, the bob will then swing up to point

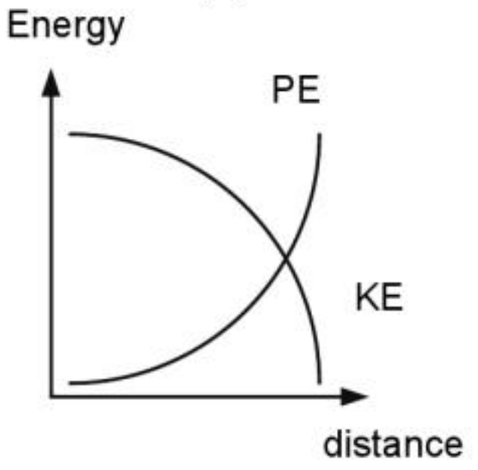


3. A ball rolls up a frictionless slope to come to a rest before it rolls down. Which of the following graphs shows the correct kinetic energy and gravitational potential energy of the ball during the up slope motion of the ball?

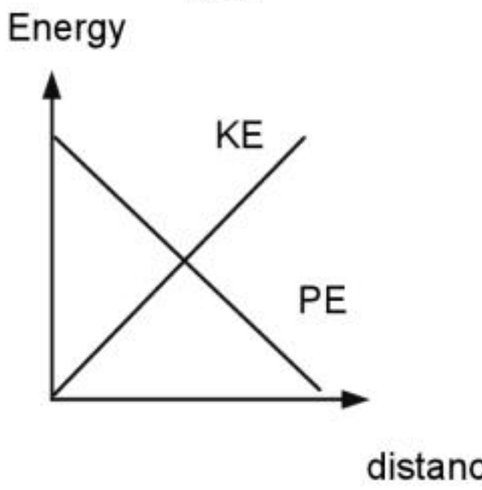
(A)



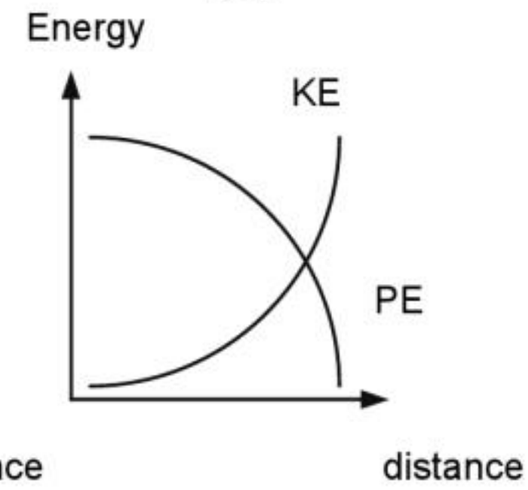
(B)



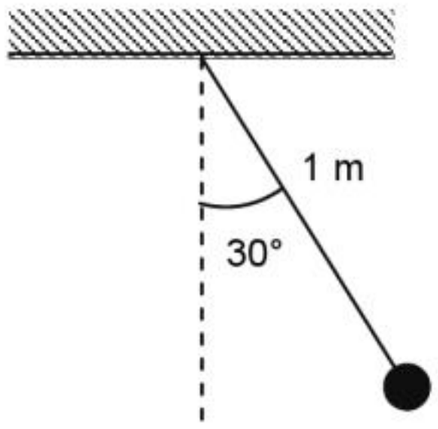
(C)



(D)



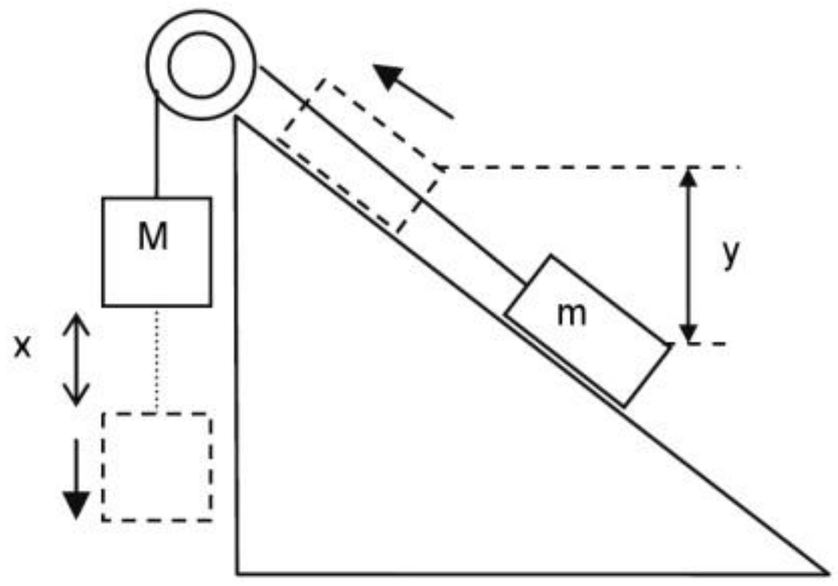
4. A one metre long pendulum bob is pulled aside by an angle of 30°. It is released from rest. What is the velocity of the bob at its lowest position?



(A) 1.05 m s^{-1} (B) 1.16 m s^{-1}

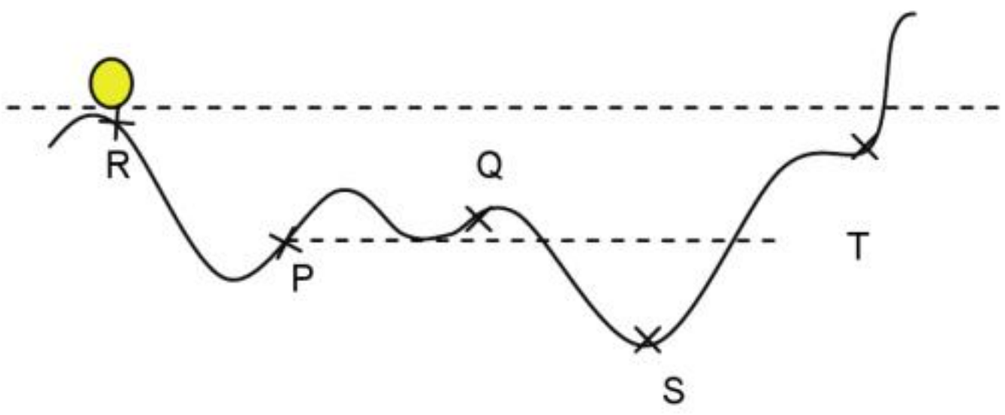
(C) 1.64 m s^{-1} (D) 1.82 m s^{-1}

5. The figure shows a mass m on an inclined plane connected by an inextensible string over a smooth pulley to a larger mass M. When the mass M falls through a distance x, the mass m moves up a vertical distance y at a constant speed. The friction between m and the inclined plane is F. What is the energy converted to heat?



(A) F (x-y)
(B) Fy
(C) Mgx – mgy
(D) (M-m) gx

6. A marble is allowed to roll along an undulating plane as shown. It is at rest at R. Neglecting air resistance and assuming the plane is smooth,



(i) the marble has maximum kinetic energy at S.

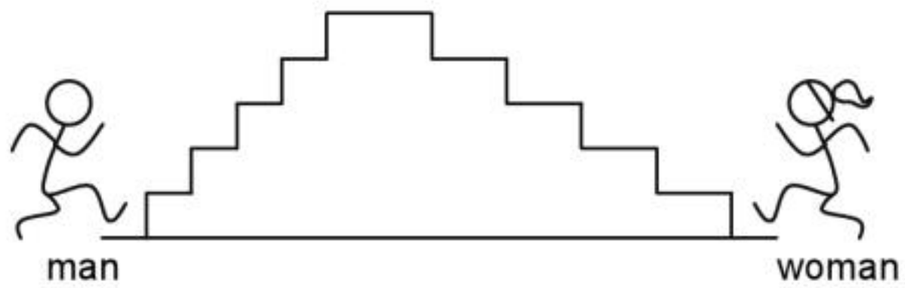
(ii) the speed of the marble a P is slightly greater than at Q.

(iii) the marble will at most roll up to T and return.

Which is/ are correct?

(A) (i) only
(B) (ii) only
(C) (i) and (ii) only
(D) (i) and (iii) only

7. Two runners run up two different flights of stairs. They reach the top at the same time. The man weights 65 kg while the woman weights 50 kg.



Which of the statements about the man is correct?

(A) He gains more potential energy.

(B) He delivers greater power.

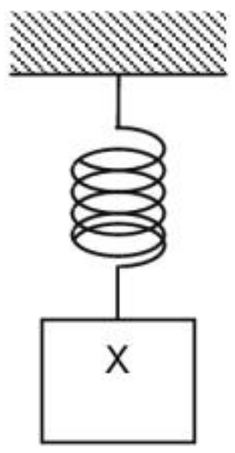
(C) He possesses greater kinetic energy.

(D) He runs at the same speed than the woman.

8. A stone of mass 0.40 kg is projected horizontally at a speed of 6.0 m s^{-1} from the top of a wall, 5.0 m above the surrounding ground. When it arrives at the ground, its speed is 10 m s^{-1}. How much energy has it lost in falling through the air? Assume g = 10 m s^{-2}.

(A) 2.4 J
(B) 2.8 J
(C) 7.2 J
(D) 14.4 J

9. A body X executes vertical undamped simple harmonic oscillations when attached to a spring as shown in the figure. Which one of the following statements is correct?



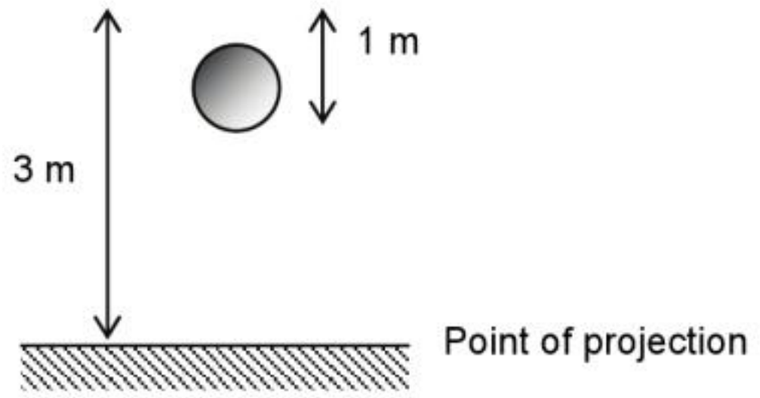
(A) The total potential energy of the system is a minimum when X is at the lowest point of its oscillation.

(B) The acceleration of X is a maximum when it passes through the centre of oscillation.

(C) The tension in the spring is a minimum when X passes through its centre of oscillation.

(D) The kinetic energy of X is a minimum when it is at the lowest point of its oscillation.

10. A 0.2 kg mass is thrown vertically upwards so that it reaches a height of 3 m above the point of projection.



What is its kinetic energy when it is 2 m above the point of projection?

(A) 10 J
(B) 6 J
(C) 4 J
(D) 2 J

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(a) Calculate

(i) the mass of water passing through the turbines each second.

(ii) the loss of potential energy per second of the water flowing between the reservoir and the power station turbines.

(iii) the efficiency of the power station.

(b) The water passes through a pipe of uniform cross-section area. Using physics of fluid, state and explain the change, if any, in the speed of the water just as it enters the power station.

(c) The turbines drive generators that produce alternating current at an r.m.s potential difference of 25 kV which is then stepped up to an r.m.s potential difference of 275 kV by means of a transformer.

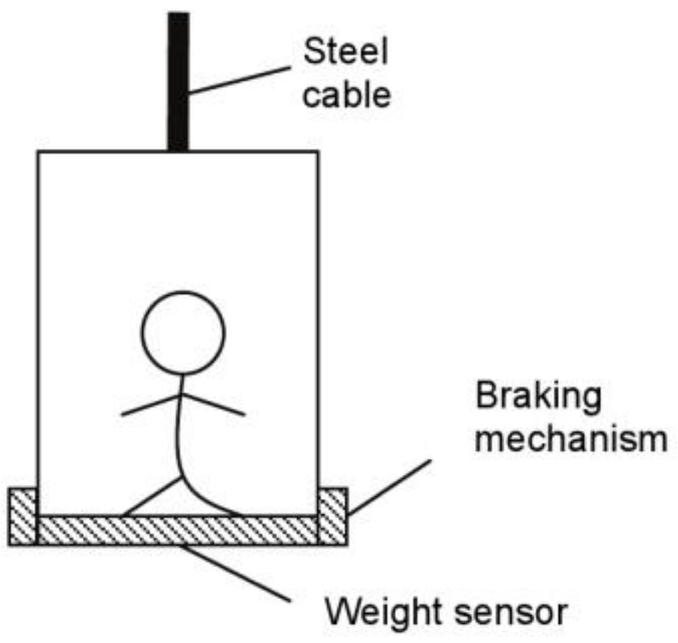
(i) Calculate the r.m.s. current supplied by the generatos to the transformer when the power output of the generators is 2.0 MW.

(ii) The transformer has an efficiency of 95 %. Calculate the output current of the transformer.

(iii) State and explain one cause of energy loss in the transformer.

(iv) Explain why it is necessary to step up the potential difference?

4. An intelligent elevator can take passengers to the top of a very tall building. The elevator has a build-in weight sensor to measure the force its passengers exert on the floor and a braking mechanism which is activated (after a short period of time) in case the steel cable snaps.



A man decides to take the elevator from the ground level to the top level of the building. He has a mass of 95 kg, and the elevator together with all its parts have a mass of 1.1×10^3 kg.

(a) From the ground level, the elevator starts to accelerate at a uniform rate of 2.0 m s^{-2}.

(i) Determine the speed of the elevator after 3.0 s.

(ii) State the kinetic energy gained after 3.0 s.

(ii) The engine of the elevator consumes 0.046 kWh of electrical energy during this 3.0 s. If the engine has an efficiency of 77 %, find the vertical distance covered by the elevator.

(b) When the elevator is near the top level, the steel cable snaps.

(i) State the reading on the weight sensor immediately after the cable broke. Explain your answer.

(ii) After a few seconds, the braking mechanism is activated and exerts a constant braking force of 2.5×10^4 N on the elevator.

1. Calculate the acceleration of the elevator.

2. State the direction of the acceleration calculated in 1.

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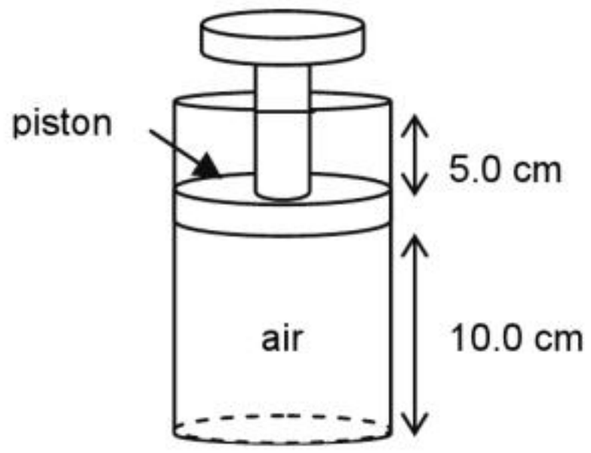
6. A piston of negligible weight encloses air at atmospheric pressure of 100 kPa in a rigid cylinder as shown. The piston is slowly pulled up by 5.0 cm such that the enclosed air stays at the same temperature.

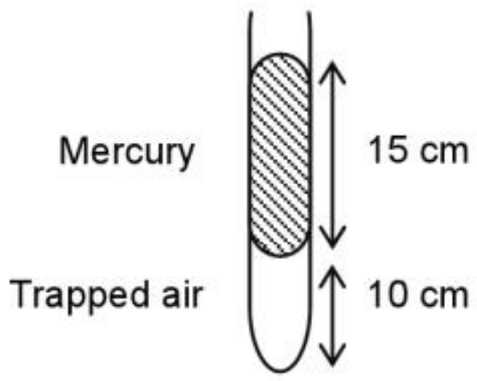


What will then be the pressure (in kPa) of the enclosed air?

(A) 67 (B) 75

(C) 100 (D) 150

7. Air is trapped in a narrow tube sealed at one end. When the atmospheric pressure is 75 cm Hg, the length of the trapped air column is 10 cm as shown. Assume temperature is kept constant throughout, what is the pressure of the trapped air?



(A) 6 cm Hg (B) 85 cm Hg

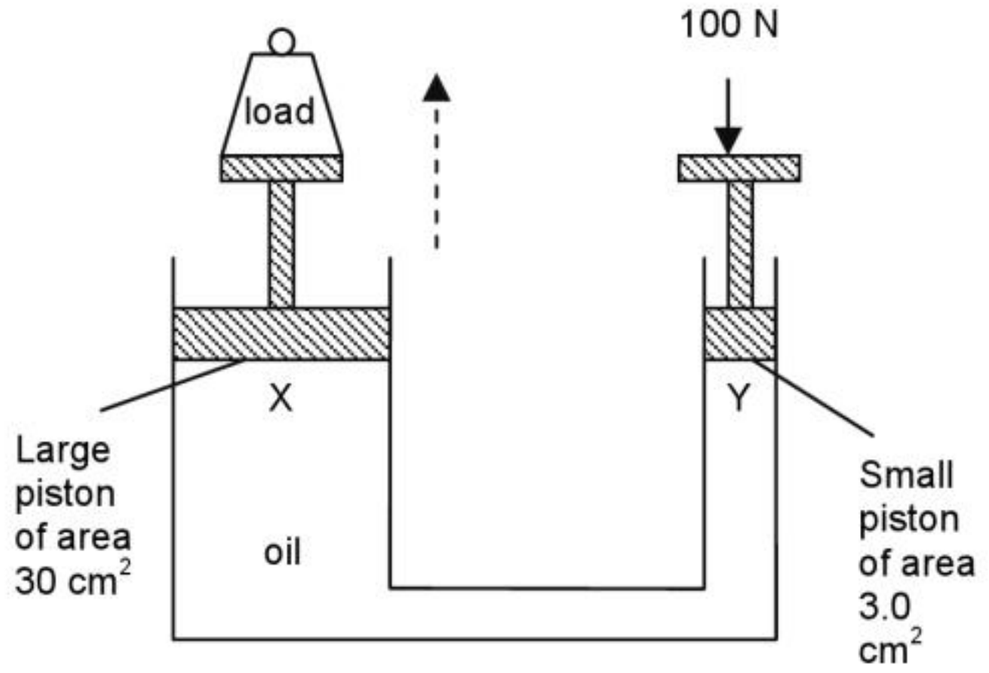
(C) 90 cm Hg (D) 100 cm Hg

8. An air bubble at the bottom of a lake experienced a pressure of 4 atmospheres. When it reaches the surface, where the pressure is 1 atmosphere, it has a volume of 6.0 cm^3. Assuming temperature is constant, what is the volume of the air bubble when it is at he bottom of the lake?

(A) 0.67 cm^3 (B) 2.0 cm^3

(C) 1.5 cm^3 (D) 24 cm^3

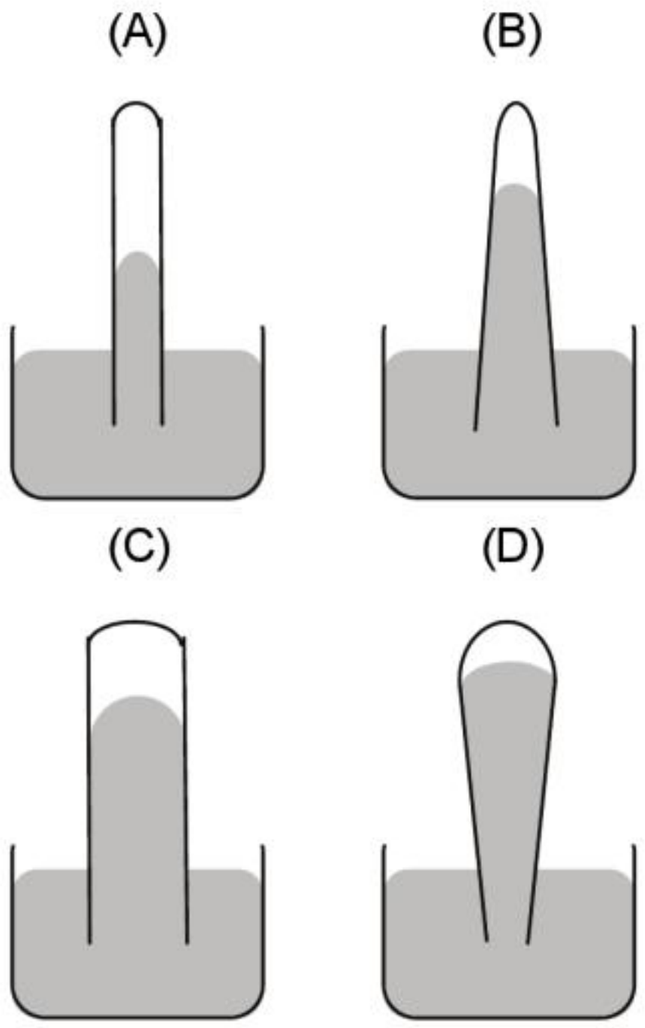
9. In a hydraulic press as shown, the small piston of 100 N is pushed down and this is just sufficient to raise a heavy load in the large piston. Neglecting the weight of the pistons, what is the maximum load that can be lifted?



(A) 10 N (B) 100 N

(C) 1000 N (D) 10 000 N

10. The diagram below shows five mercury barometers. For which of these is the external pressure greatest?



11. The pressure produced by a cubic block is P. Find the pressure if length l is doubled.

(A) $\frac{P}{4}$ (B) $\frac{P}{2}$

(C) $2P$ (D) $4P$

12. Some air is trapped in the space above the mercury in a barometer. Let *l* be the height of the air column trapped and h be the height of the mercury column. When the glass tube is pressed down into the mercury bath, which of the following best describes the change of *l* and *h*?

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1.7.2 Pressure changes

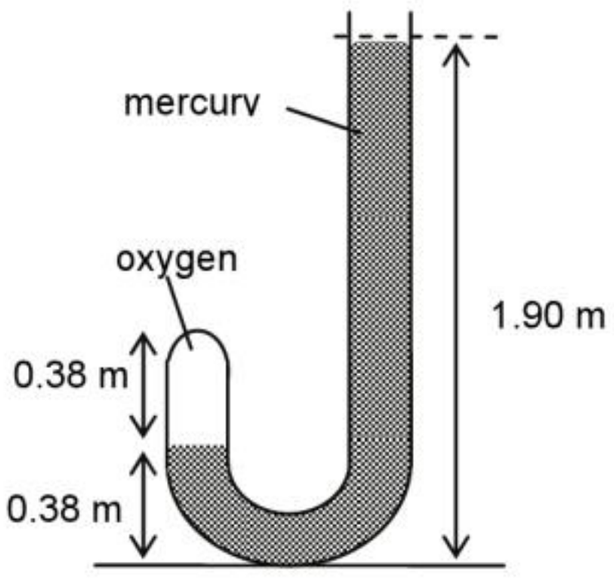
MCQs

1. A container at room temperature has one mole of hydrogen, with mass 0.002 kg and one mole of oxygen, with mass 0.032 kg. what is the ratio of the pressure of the hydrogen to the oxygen on the container wall? (Assume the gases are ideal gases.)

(A) 16 : 1 (B) 4 : 1

(C) 1 : 1 (D) 1 : 4

2. Oxygen is compressed in the sealed end of a long J-tube by means of a column of mercury open to the atmosphere, as shown.



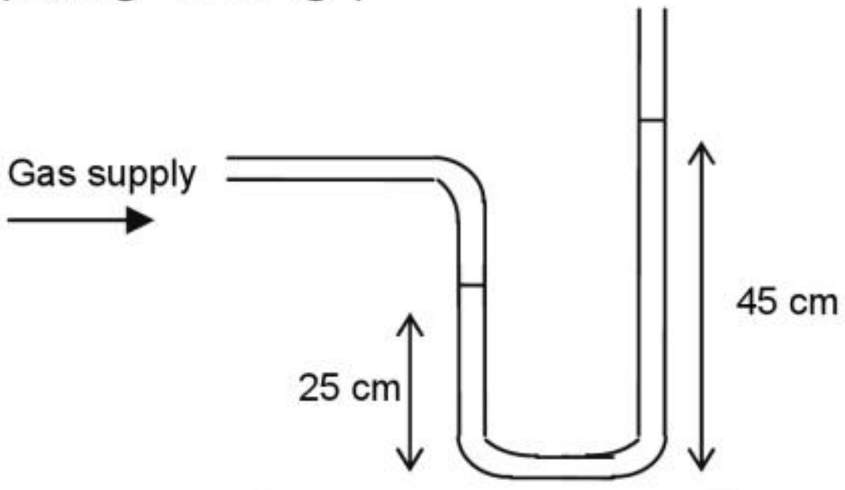
If atmospheric pressure is 0.76 m of mercury, what is the ratio of the pressure of the oxygen to that of the atmosphere?

(A) 1.5 : 1 (B) 2.0 : 1

(C) 2.5 : 1 (D) 3.0 : 1

3. The manometer is filled with a liquid of density 880 kg m^{-3}. The gas pressure is in excess of atmospheric pressure is

(Take g = 10 N kg^{-1})



(A) 880 N m^{-2} (B) 1760 N m^{-2}

(C) 2200 N m^{-2} (D) 3960 N m^{-2}

4. A balloon filled with helium was released from the bottom of a tall building at sea level.

At the bottom of the building, the balloon had a volume of 500 cm^3, while at the top, the volume was found to be 510 cm^3.

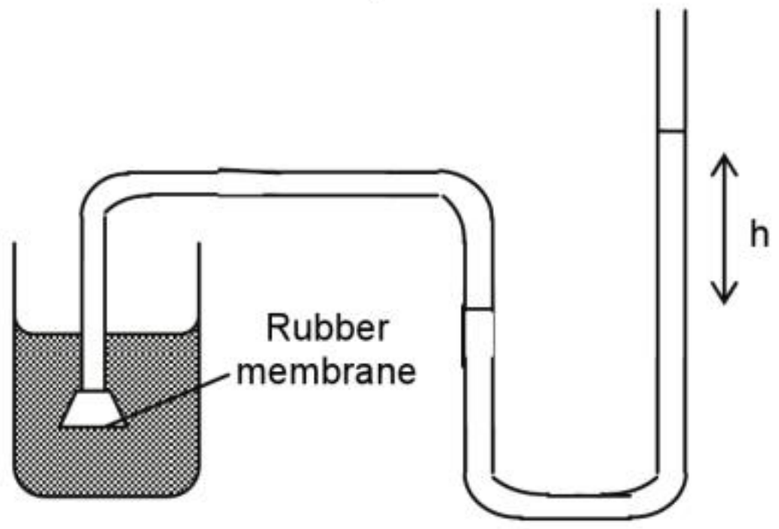
The pressure at sea level is 100 kPa.

If the density of air is 1.29 kg m^{-3}, what is the height of the building?

(A) 126 m (B) 132 m

(C) 152 m (D) 760 m

5. A funnel which has a rubber membrane stretched over its mouth is connected to a manometer and immersed in a tank of liquid.



The difference, h, in the liquid levels of the manometer could be increased by increasing the

(A) density of the liquid in the tank.

(B) density of the liquid in the manometer.

(C) area of rubber membrane.

(D) cross-sectional area of the manometer tubing.

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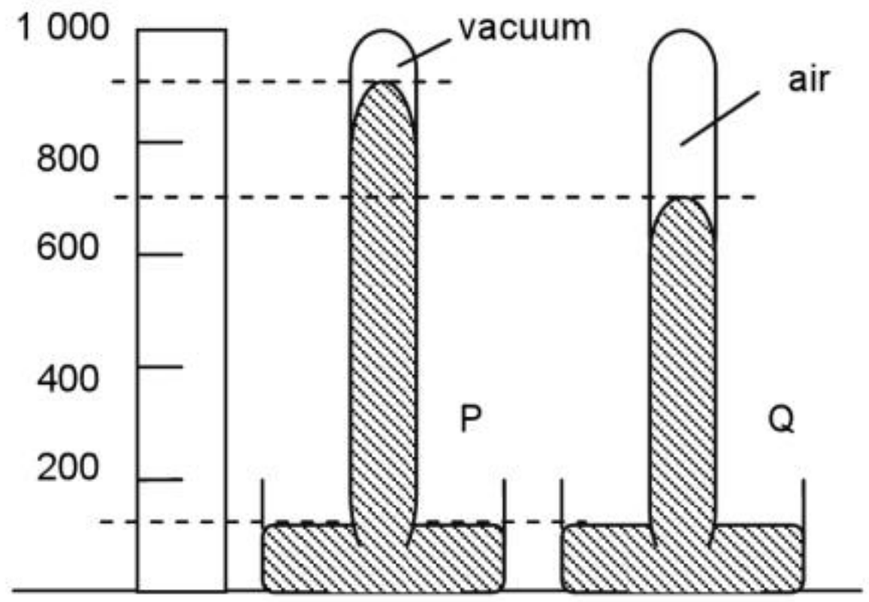
4. The figure shows a mercury barometer P and another tube Q which has a little air tapped in it.



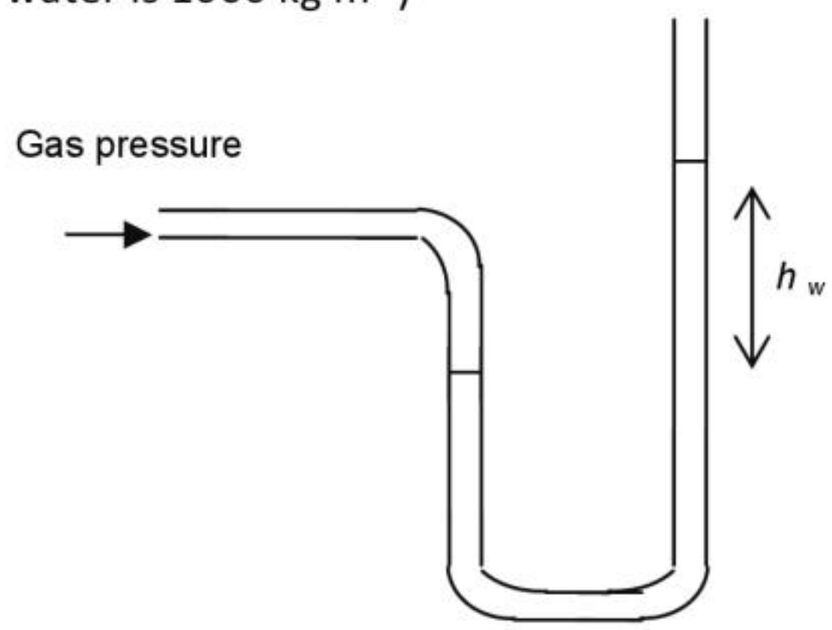
(a) What is the pressure of the air in tube Q, in cm mercury?

(b) The tube Q is then pushed downwards so that the lower end is deeper in the bowl of mercury. How does the length of the air column in the tube change?

(c) Hence, explain how this will affect the difference in the mercury levels between tube Q and the bowl.

5. The diagram below shows a manometer containing water. A gas pressure of 102 kPa is supplied through the opening and the water level on the right-hand tube of the manometer is pushed up. The difference in the water levels in both tubes of the manometer is denoted by h_w.

(Atmospheric pressure is 1.00×10^5 Pa, density of water is 1000 kg m^{-3})



(a) Calculate the height h_w.

(b) The as is removed and certain amount of oil is poured into the left-hand of the manometer such that the water level on the right-hand tube of the manometer remains the same as in (a). What is the height of this column of oil? (Density of oil is 800 kg m^{-3})

(c) What would be the difference in height between the two liquid levels if the diameter of the right-hand tube were double that of the left-hand tube?

6. Fig 6.1 below represents a simple mercury barometer on a particular day. The scale alongside the barometer is marked in mm.

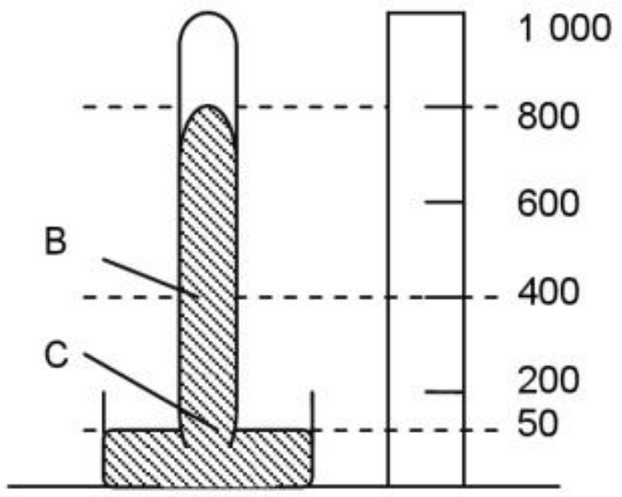


Fig 6.1

(a) What is the pressure, inside the tube in Fig 6.1

(i) at point C?

(ii) at point B?

(b) The mercury levels shown inside the tubes in Fig 6.2 and 6.3 are incorrect.

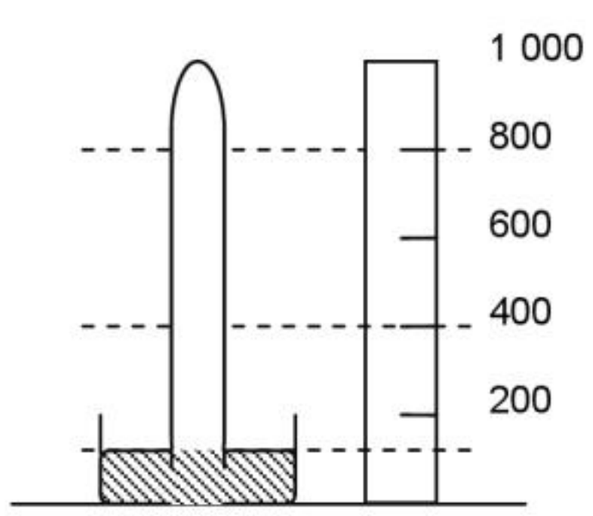


Fig 6.2

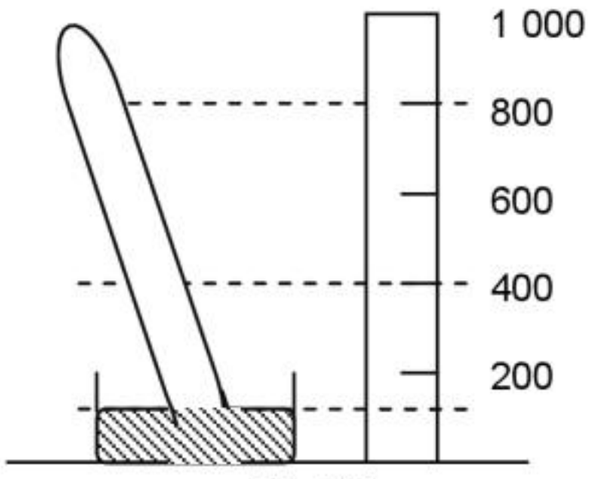


Fig 6.3

(i) On Fig 6.2, show the correct level of mercury inside the tube after pouring more mercury into the reservoir until it reaches the level shown by the dotted line in the diagram.

(ii) On Fig 6.3, show the correct level of mercury inside the tube after tilting the

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Answer keys:

1.7.1

MCQs

1. B
2. C
3. D
4. C
5. C
6. A
7. C
8. C
9. C
10. D
11. C
12. C
13. C
14. C
15. C

Questions

1. h = 320 mm
2. (a)(i) 0.250
   0.370
   0.50
   0.625
   0.770
   (a)(iii) a straight line with gradient i.e. $P \propto \frac{1}{V}$
   (b)(i) 1 m^3
   (b)(ii) 400
   (b)(iii) temperature remains the same
3. (a)(i) 90 N cm^{-2}
   (a)(ii) 90 N cm^{-2}
   (a)(iii) 36000 N
   (b)(i) 100 cm^3
   (b)(ii) 0.25 cm
   (c) valve A opens
   valve B closes
4. (a) 658 mm
   (b) 25 cm
6. (b)(i) 70 N cm^{-2}
   (b)(ii) 70 N cm^{-2}
   (b)(iii) 98 N

1.7.2

MCQs

1. C
2. D
3. B
4. C
5. A

Questions

2. (a)(i) $p = dgh$
   (a)(ii) $U = dhAg$
   (a)(iii) $W = \rho(h+y)Ag$
   (a)(iv) $y = h(d+\rho)\rho$
   (b) $y \geq 0$, implying that $d \geq \rho$
3. (a) total pressure $= h\rho g + P_{atm}$

1.7.3

MCQs

1. A
2. A
3. B
4. B
5. A

Questions

1. (a) 2.04×10^4 Pa
   (b) Q shorter
   P remains unchanged
2. (a) same level as K
   (b) 0.0132 m
   (c) 0.0053 m
3. (a) the atmospheric pressure is 760 mm Hg
   (b) 1.03×10^5 Pa
4. (a) 20 cm Hg
   (b) length of air column decreases
5. (a) 0.204 m
   (b) 0.255 m
   (c) 0.051 m
6. (a)(i) 750 mm Hg
   (a)(ii) 400 mm Hg

1.7 – 14

Notes:

2

THERMAL PHYSICS

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Questions – 2.1(a)

1. Oxygen has a boiling point of -183°C and a melting point of -218°C. Describe briefly how oxygen at 0°C and oxygen at -246°C differ in respect of

(a) spacing of the molecules.

(b) motion of the molecules.

2.1(b) Molecular model

MCQs

1. In a Brownian motion experiment involving smoke particles in the air, heavy particles settle quickly but very small particles remain suspended for long periods of time. This is because

(A) air pressure has a greater effect on smaller particles.

(B) random molecular bombardment by air molecules keeps the particles suspended.

(C) the Earth's gravitational field does not act on very small particles.

(D) the small smoke particles have the same density as air.

2. Brownian motion shows that

(A) air molecules exist and can reflect light from the light source into the microscope.

(B) air molecules move about randomly and at high speeds.

(C) smoke particles behave like air molecules.

(D) smoke particle and air molecules move about randomly.

3. The Fig 3.1 shows smoke particles in a transparent box observed using a microscope. Small points of light are seen to move around as shown in Fig 3.2.

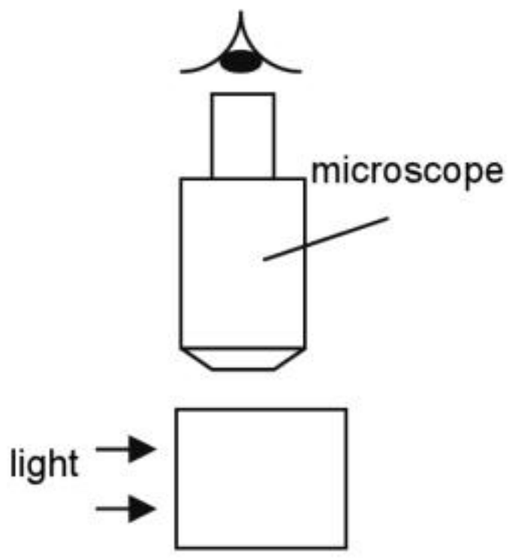

Fig 3.1

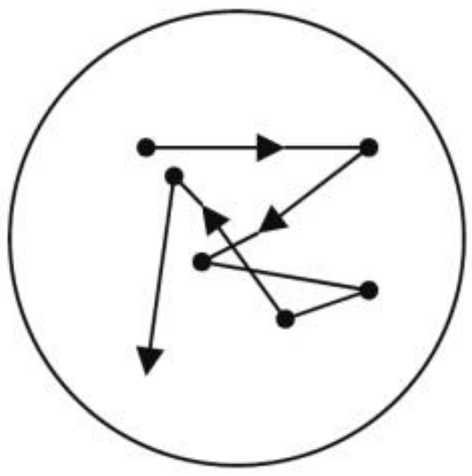

Fig 3.2

What does this experiment demonstrate about air molecules?

(A) They are in continuous random motion.

(B) They move more quickly when they are heated.

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2.0 kW under steady state conditions. Neglect all thermal losses.

(b) State and justify qualitatively how the rate of production of distilled water is different

1. before a steady state is reached,

2. when there are thermal losses from the still in a steady state.

3. A 100 g packet of frozen peas at 0 ˚C is taken from the cold compartment of a refrigerator. After 20 min, the ice has completely melted and produced 5 g of water.

(a) Assuming that the peas and the water are still at 0˚C, calculate the rate at which heat has been gained from the surroundings to melt the ice. Assume that the specific latent heat of melting ice is 340 J g^{-1}.

(b) (i) Suggest why the rate of gain of heat might have been larger than the value you have calculated.

(ii) If the peas and water are left for several more minutes, the rate of gain of heat decreases. Suggest why this is so.

4. The label on an electric kettle is marked '240 V, 3 kW '. One such kettle contains 1.7 kg of water at 20 °C. It takes 3.5 min to raise the temperature of the water to 100°C. It takes a further 3.5 min to boil away 0.23 kg of the water.

(The specific heat capacity of water is 4.2 kJ kg^{-1} K^{-1}. The specific latent heat of vaporization of water at 100°C is 2.3 MJ kg^{-1}.)

(a) State the meaning of '240 V, 3 kW '.

(b) Calculate

(i) the energy output of the electric element in the kettle in 3.5 min.

(ii) the energy required to raise the temperature of 1.7 kg of water from 20°C to 100°C.

(iii) the energy required to boil away 0.23 kg of water at 100°C.

(b) Estimate the unused power (*i.e.*, average rate of energy 'loss')

(i) during the first 3.5 min.

(ii) during the second 3.5 min.

(d) Suggest why the two rates of 'loss' are different. As part of your answer, consider possible energy changes in the body of the kettle.

2.2(e) Specific latent heat

MCQs

1. On a cold winter morning Sharon wakes up to find that moisture has condensed on the inside of her bedroom window. Which of the following is true?

(A) The temperature of the room has decreases because latent heat fusion is given out by the air in the room.

(B) The temperature of the room has increased because latent heat of vaporization is given out to the air outside the window.

(C) The temperature of the room has decreased because latent heat of vaporization is given out by the air in the room.

(D) The temperature of the room has increased because latent heat of fusion is given out to the air outside the window.

2. 0.1 kg of ice at 0°C is dropped into 1.0 kg of water at 18°C. If the specific heat capacity of water is 4 200 J kg^{-1} $°C^{-1}$ and the specific latent heat of fusion of ice is 336 000 J kg^{-1}, what is the final temperature of the mixture?

(A) 4°C (B) 6°C

(C) 8°C (D) 10°C

3. An aluminium calorimeter of mass 0.50 kg is filled with 1.20 kg of water at 20.0°C. When 1.00 kg of solid mercury at its melting point of – 39.0°C is placed in the calorimeter, the final temperature of the mixture is found to be 16.5°C.

Using the information below, what is the specific latent heat of fusion of mercury? You are to assume that heat loss to the surroundings is negligible.

Specific heat capacity of mercury = 140 J kg^{-1} $°C^{-1}$
Specific heat capacity of water = 4 200 J kg^{-1} $°C^{-1}$

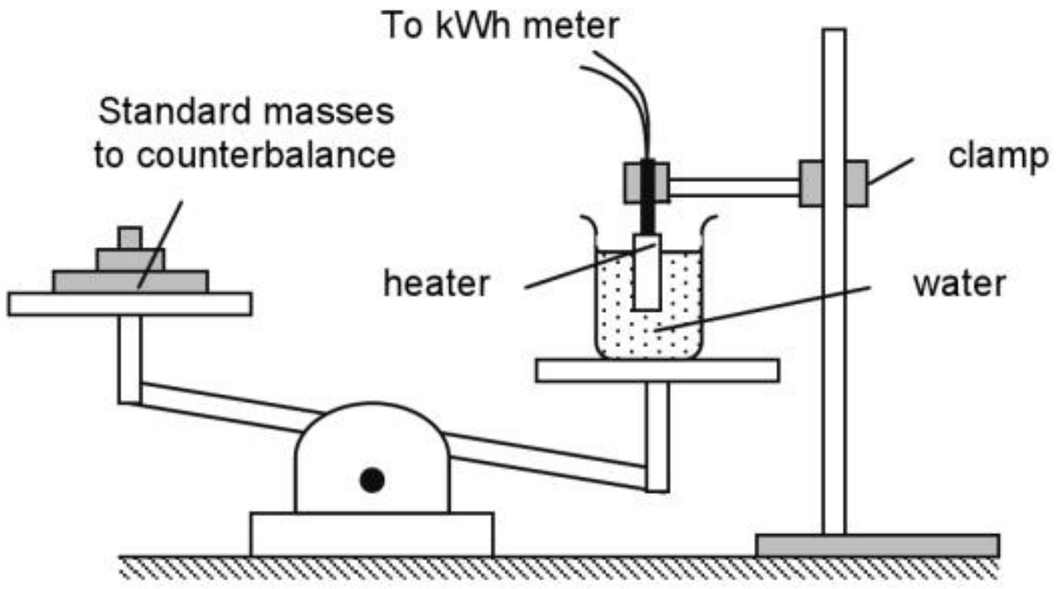
Specific heat capacity of aluminium = 900 J kg^{-1} $°C^{-1}$

(A) 11.4 kJ kg^{-1} (B) 15.4 kJ kg^{-1}

(C) 19.4 kJ kg^{-1} (D) 23.4 kJ kg^{-1}

Questions – 2.2(e)

1. The figure below shows one way to measure the specific latent heat of vaporization of steam in the laboratory. A mains immersion heater that is connected to a kilowatt-hour kWh) meter is used to boil off water at 100 °C from a container. By recording the amount of energy supplied and the mass of water boiled off, the specific latent heat of vaporization of steam can be found.



Two-pan balance

(a) The two-pan balance is usually set to become horizontal in the first place. However, this cannot be achieved by adding standard masses to the left pan of the balance.

(i) Why is this so?

(ii) Suggest one way to make the pan balance?

(b) When the two-pan balance s in equilibrium and the water is boiling, a 300 g mass is then added to the right pan to tilt the two-pan balance. The kilowatt-hour meter which reads the total amount of energy supplied to the heater reads 8.0 kWh then. As the water boils off, the right pan rises to attain its equilibrium again and the meter then reads 8.3 kWh.

(i) What is the weight of the water that has boiled off?

(ii) Calculate the specific latent heat of vaporization of steam if 40 % of electrical energy is lost to the surroundings.

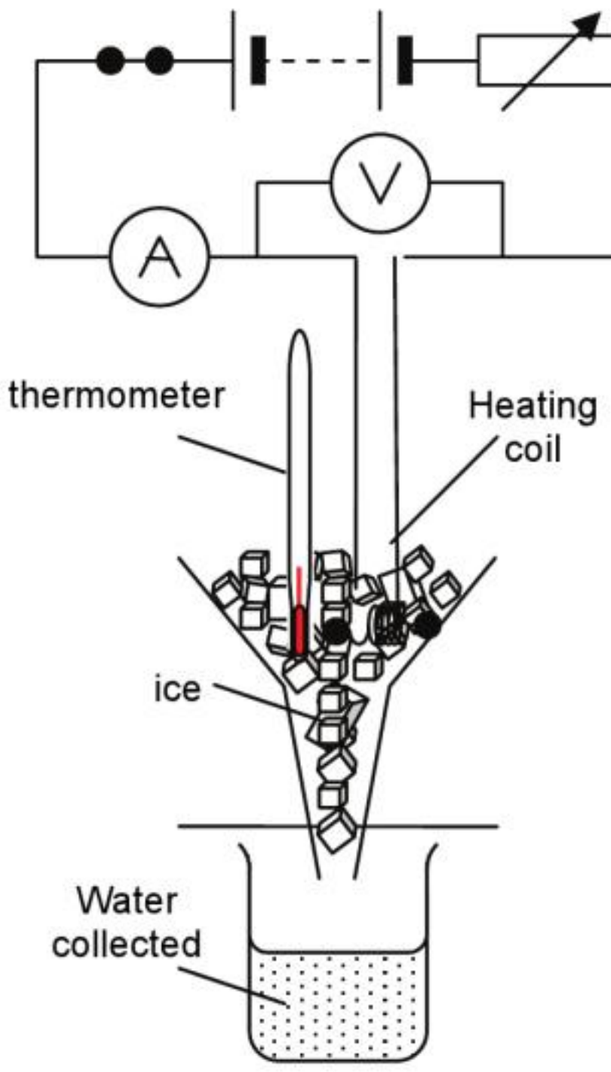
(iii) In another experiment, the student pushes a larger portion of the heater into water. Describe and explain the effect that it has on the value in (b)(ii).

(iv) Would the experiment be improved if the container of boiling water is covered? Explain why?

(v) What is meant by latent heat of vaporization?

2. (a) State what is meant by specific latent heat of fusion of ice.

(b) A student performed an experiment using the apparatus as illustrated in the figure below.



A heating coil was placed in a filter funnel and surrounded by lumps of ice. The potential difference V across the heater and mass m of water collected in time t of 500 s were measured for various values of the heater current I.

The values were recorded and a spreadsheet was used to make calculations as shown in the table below.

	1	2	3	4	5	6
A	Potential difference, V	/ V	4.0	6.0	7.0	8.0
B	Current, I	/ A	2.0	3.0	3.5	4.0
C	Mass of water collected, m	/ g	14.9	29.8	39.5	50.6
D	Time taken, t	/ s	500	500	500	500
E	Thermal energy supplied	/ J	4000	9000	12250	

(i) Explain how the values for the thermal energy supplied by the heating coil in column E were calculated from the relevant columns in the table.

(ii) Calculate the thermal energy supplied when the mass of the water collected was 50.6 g.

The student wishes to find out the value of the specific latent heat of fusion of ice. He chose the values from row 5 to do the calculation.

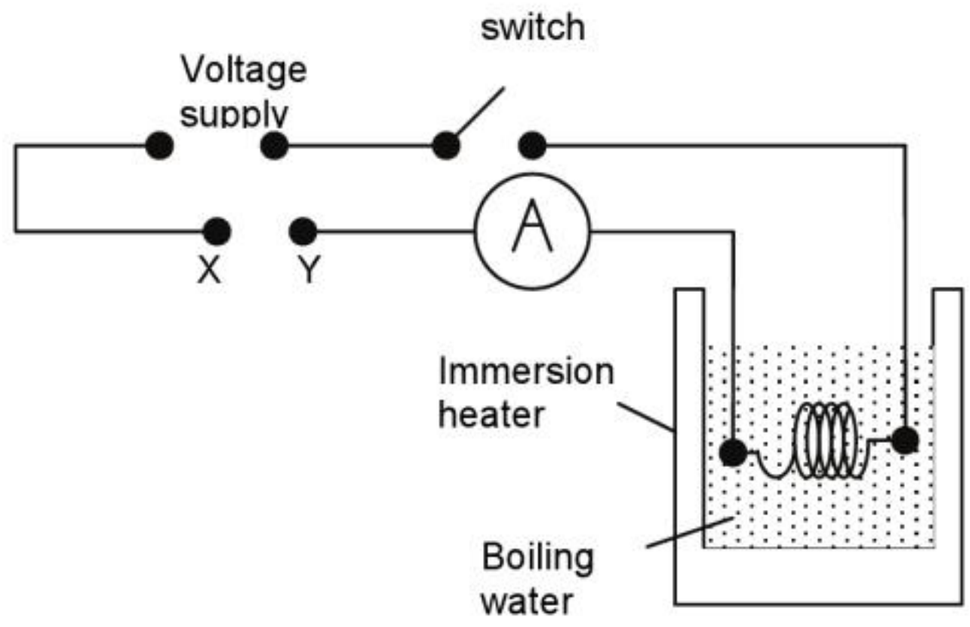
(iii) Write down the energy equation that will help him get started.

(iv) Hence, determine the value of the specific latent heat of fusion of ice.

Later, the student discovered that all the four values of the specific latent heat of fusion of ice calculated from each row of data were less than the actual value of 336 J g^{-1}.

(v) Suggest a reason to explain the discrepancy.

3. The figure shows part of an experimental arrangement which is to be used to obtain a value for L, the specific latent heat of vaporization of water.



(a) (i) Assuming that the voltage provided by the supply is fixed, add a suitable component between terminals X and Y which will enable the power supplied to the heater to be varied.

(ii) Show on the diagram how you would connect a voltmeter so that the power supplied to the heater can be determined.

(iii) Describe the procedure you would use and state the measurements you would make to determine L.

(b) In a particular experiment using the apparatus in the figure shown in (a), 36000 J of energy were supplied to the heater and 0.015 kg of water vaporized.

(i) Calculate a value for L.

(ii) State and explain whether you would expect your answer to be higher or lower than the accurate value of L.

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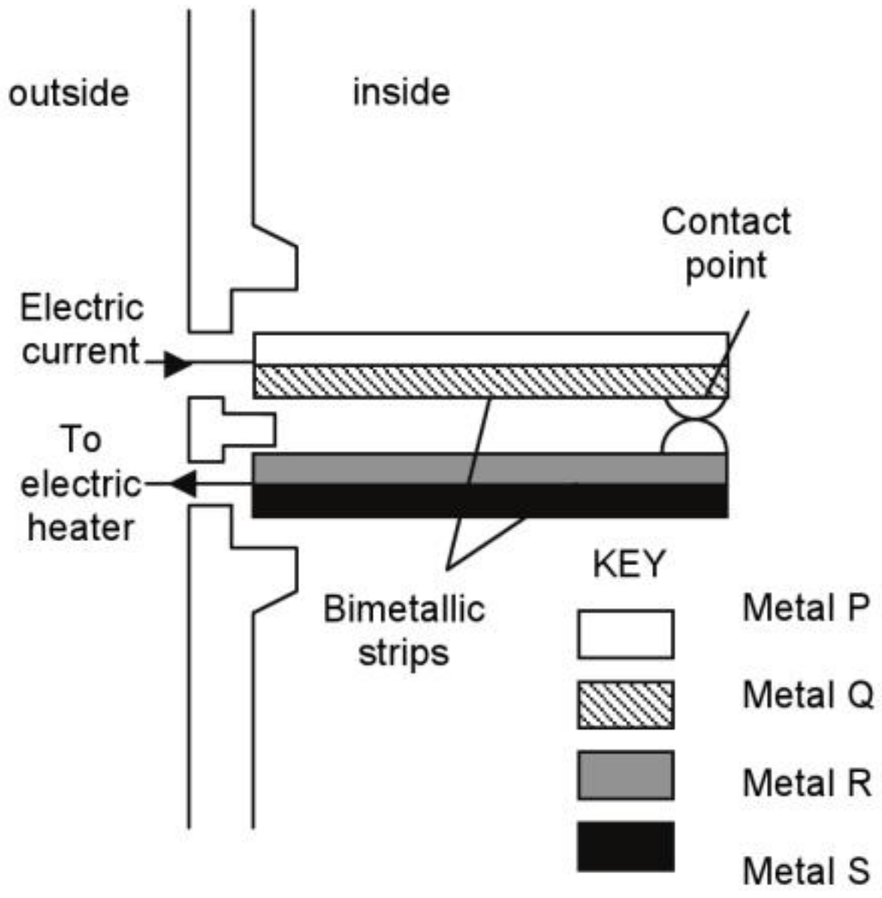
10. An electric kiln has a device in it to prevent the kiln from getting too hot. The metals in the bimetallic strip expand at different rates and bend when heated. The contact points move apart and electric current stops flowing.



In order for this device to work,

(A) Q expands more than R, and P expands more than S.

(B) R expands more than S, and Q expands more than P.

(C) P expands more than Q, and R expands more than S.

(D) P expands more than R, and S expands more than Q.

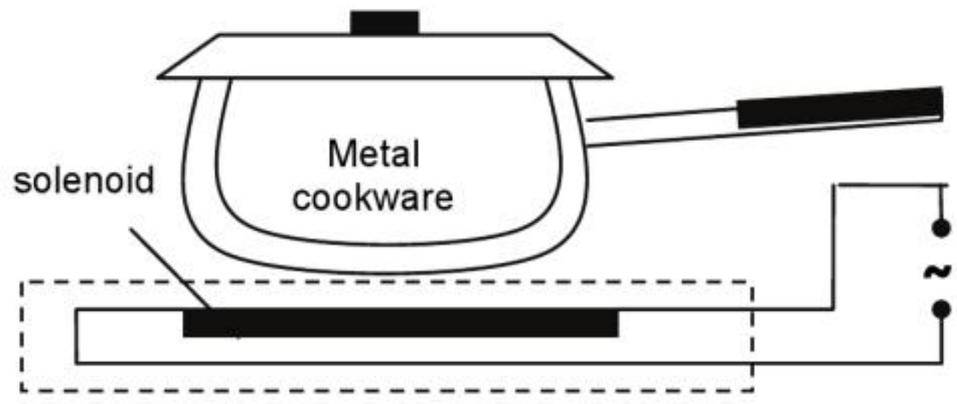
Questions – 2.3(a)

1. (a) Explain why newspaper wrapping keeps hot things hot, e.g. fish and chips, and cold things cold, e.g. ice cream.

(c) Explain why in certain countries, salt water is sprayed on an icy road in a mild winter by the traffic authorities.

(d) Explain in terms of the kinetic theory of gases why boiling occurs at a fixed temperature whereas evaporation happens at any temperature.

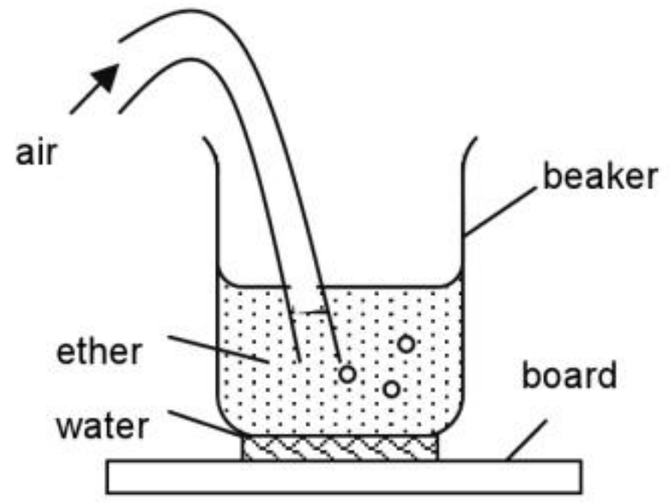
2. The figure below shows an induction stove. A solenoid in the stove produces a varying magnetic field, which cases the metal cookware to be heated up when they are placed in the field.



(a) Explain whether the cookware used with an induction heater for cooking should be thick or thin.

(b) Explain whether a cookware made of anon-ferrous metal can be used with an induction stove.

3. The diagram shows a beaker containing ether which stands on a wooden board. There is a thin film of water between the board and the base of the beaker. Air is then blown through the tube so that it bubbles out from the immersed end. This causes the ether to evaporate more rapidly.



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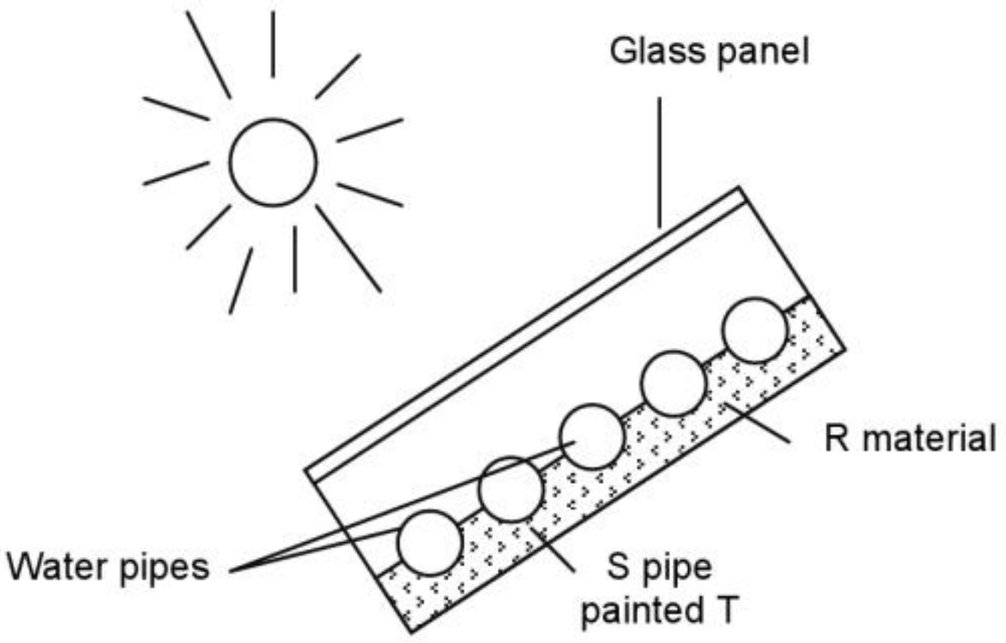
4. A cross-section of a solar panel is shown below. In the labeling, three key words have been replaced by the letters, R, S and T.



Which are the best words to replace these letters?

	R	*S*	*T*
(A)	Cheap	Lead	Black
(B)	Straw	Iron	White
(C)	Insulating	Copper	Black
(D)	Natural	Zinc	Silver

5. In a vacuum flask, which is the component that reduces radiation?

(A) The silvered wall

(B) The stopper

(C) The vacuum between the walls

(D) The foam supporting the walls

6. In an oil refinery, petrol storage tanks are painted with a light colour to reduce

(A) energy gained by conduction.

(B) energy gained by convection.

(C) energy loss by conduction.

(D) energy loss by radiation.

7. A student investigates changes that may take place as sulphur solidifies. Which of the following correctly describes these changes?

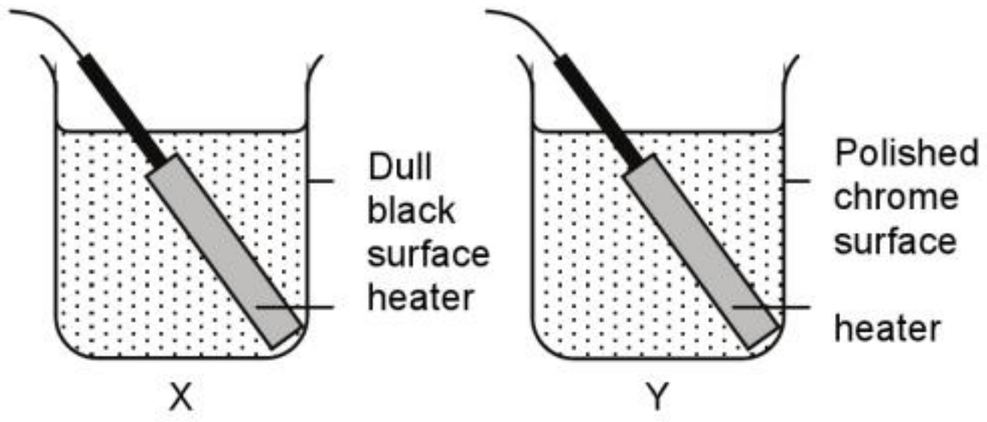
(A) A transfer of energy and a change in temperature.

(B) A transfer of energy but no change in temperature.

(C) No transfer of energy and no change in temperature.

(D) No transfer of energy and a change in temperature.

8. In the diagram, two copper cans X and Y with outer surface of different texture are filled with same amount of water at room temperature and heated by heaters of same power.



Which of the following statements is correct?

(A) Water in X boils faster because dull surface is a good absorber.

(B) Water in X boils faster because dull black surface is a better insulator.

(C) Water in Y boils faster because polished chrome surface is a poor radiator.

(D) Water in both cans take same length of time to boil because texture of outer surface will not affect the rate of energy absorbed by the water.

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2.4

MEASUREMENT OF TEMPERATURE

2.4.1 Principles of thermometry

2.4.2* Liquid–in–glass thermometers

2.4.3* Thermocouple thermometers

Learning Outcomes

Candidates should be able to:

(a) explain how a physical property which varies with temperature, such as volume of liquid column, resistance of metal wire and electromotive force (e.m.f.) produced by junctions formed with wires of two different metals, may be used to define temperature scales

(b) describe the process of calibration of a liquid–in–glass thermometer, including the need for fixed points such as the ice point and steam point

2.4.1 Principles of thermometry

Questions – 2.4.1

1. (a) List 3 physical properties of matter that can be used for thermometry and state one example each.

(b) For one of the listed properties, state one advantage and one disadvantage.

2.4.2 Liquid-in-glass thermometers

MCQs

1. The stem of a liquid-in-glass thermometer is specially designed. Which of the following statements describes this design correctly?

(A) The stem is made long so that the thermometer will be more sensitive.

(B) The stem is made short so that the thermometer will be more sensitive.

(C) The stem is made narrow so that the thermometer will be more sensitive.

(D) The stem is made wide so that the liquid will flow easily.

2. A thermometer reads -1.0°C in pure melting ice and 99.0°C in steam above boiling water. When used to measure the temperature of an unknown liquid before and after it is heated, the thermometer gives a reading of 20.0°C and 28.0°C respectively. What is the actual change in the temperature of the liquid?

(A) 7.0°C (B) 8.0°C

(C) 9.0°C (D) 10.0°C

3. Which of the following modifications to a liquid-in-glass thermometer will not work?

(A) To use a bigger bulb (containing more mercury) so as to improve the sensitivity of the thermometer.

(B) To use a thinner bulb wall so as to make the thermometer more accurate.

(C) To use a narrow capillary bore so as to make the thermometer more sensitive.

(D) To use a liquid with low specific heat capacity so as to shorten the time needed for a reading to be taken.

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3. When the junctions A and B of a thermocouple are kept at 250 K and the triple point temperature of water respectively, an e.m.f. of 3.5 mV is read from a potentiometer circuit. If the junction B is now removed and placed in a certain liquid, an e.m.f. of -1.2 mV is obtained. What is the temperature given by the thermocouple?

(A) - 31°C (B) - 7.9°C

(C) - 15°C (D) 7.9°C

4. Which one of the following thermometers would be most suitable for monitoring the temperature of gases in a factory chimney if the temperature can vary over a range of 200 K in a minute?

(A) Alcohol-in-glass thermometer

(B) Mercury-in-glass thermometer

(C) Thermocouple thermometer

(D) Platinum resistance thermometer

Questions – 2.4.3

1. (a) Name the physical property which varies with temperature and which is made use of in

(i) a mercury-in-glass thermometer.

(ii) a thermocouple thermometer.

(b) State

(i) two advantages of a mercury-in-glass thermometer.

(ii) two advantages of a thermocouple thermometer.

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3.1 GENERAL WAVE PROPERTIES

Learning Outcomes

Candidates should be able to:

Core

- Describe what is meant by wave motion as illustrated by vibration in ropes and springs and by experiments using water waves
- Use the term *wavefront*
- Give the meaning of *speed*, *frequency*, *wavelength* and *amplitude*
- Distinguish between transverse and longitudinal waves and give suitable examples
- Describe the use of water waves to show:
  - reflection at a plane surface
  - refraction due to a change of speed
  - diffraction produced by wide and narrow gaps

Supplement

- Recall and use the equation $v = f\lambda$
- Interpret reflection, refraction and diffraction using wave theory

3.1.1 Describing wave motion

MCQs

1. Water waves in a ripple tank move from a shallow region to a deeper region. Which one of the following options correctly describes the change, if any, in the frequency, wavelength and speed of the waves?

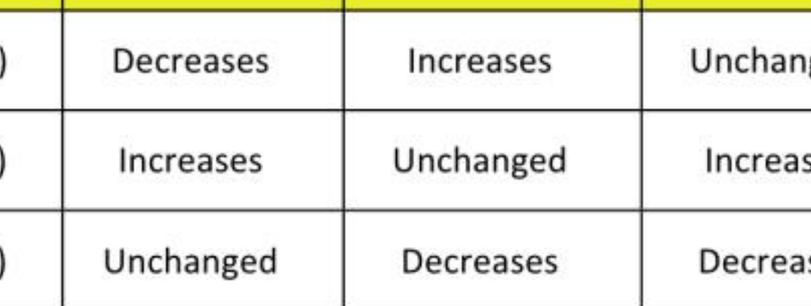
	Frequency	Wavelength	Speed
(A)	Unchanged	Increases	Increases
(B)	Unchanged	Increases	Decreases
(C)	Increases	Increases	Increases
(D)	Decreases	Decreases	Decreases

2. What happens to the speed, frequency and wavelength of light when it enters glass from air?

	Speed	Frequency	Wavelength
(A)	Decreases	Increases	Unchanged
(B)	Increases	Unchanged	Increases
(C)	Unchanged	Decreases	Decreases
(D)	Decreases	Unchanged	Decreases

3. The diagram shows a transverse wave on a rope. The wave is traveling from left to right.

At the instant shown, the points P and Q on the rope have zero displacement and maximum displacement respectively.



Which of the following describes the direction of motion, if any, of the points P and Q at this instant?

	Point P	Point Q
(A)	Downwards	Stationary
(B)	Stationary	Downwards
(C)	Stationary	Upwards
(D)	Upwards	Stationary

4. Transverse progressive sinusoidal waves of wavelength λ are passing vertically along a horizontal rope. P and Q are points on the rope $5\lambda/4$ apart and the waves are traveling from P to Q.

Which one of the following correctly describes Q at an instant when P is displaced upwards but is moving downwards?

	Displacement of Q	Movement of Q
(A)	Upwards	Downwards
(B)	Upwards	Upwards
(C)	Downwards	Upwards
(D)	Downwards	Stationary

5. A vibrator sends ripples across the surface of water. They run closer together as they travel further from the vibrator.

This shows that the ripples

(A) decrease in frequency.

(B) increase in frequency.

(C) slow down.

(D) speed up.

6. A dipper moving up and down makes waves in a ripple tank. What will happen when the dipper frequency is increased?

(A) The waves will be closer together.

(B) The wave peaks will be higher and the troughs lower.

(C) The waves will move more quickly across the tank.

(D) The waves will move more slowly across the tank.

4. A circular bowl of diameter 400 mm contains water at rest. If its side is tapped gently, a completely circular pulse can be produced on the surface of the water which travels inwards with a speed of 250 mm s^{-1}. The radius of the pulse and its direction of travel, 1 second after the pulse is produced, are

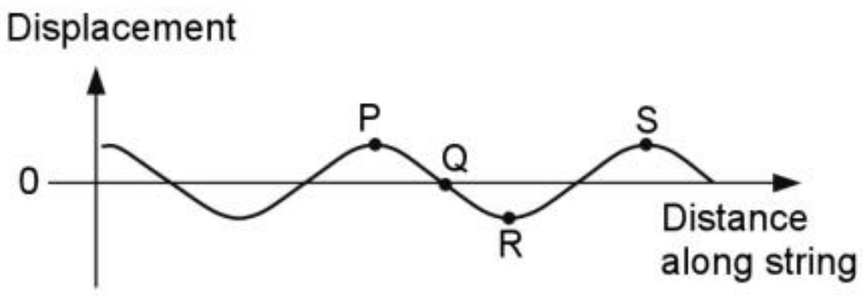
(A) zero, stationary.

(B) 50 mm, outwards.

(C) 50 mm, inwards.

(D) 150 mm, outwards.

5. The graph shows the shape at a particular instant of part of a transverse wave traveling along a string.



Which statement about the motion of elements of the string is correct?

(A) The speed of the element at P is a maximum.

(B) The displacement of the element at Q is zero.

(C) The energy of the element at R is entirely kinetic.

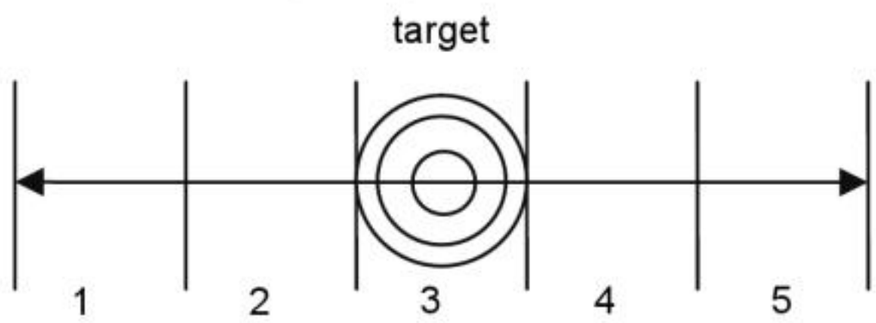
(D) The acceleration of the element at S is a maximum.

6. Visible light has wavelengths between 400 nm and 700 nm, and its speed in a vacuum is 3.0×10^{8} m s^{-1}. What is the maximum frequency of visible light?

(A) 1.2×10^{11} Hz (B) 4.3×10^{11} Hz

(C) 4.3×10^{14} Hz (D) 7.5×10^{14} Hz

7. In a fairground shooting game, a gun fires at a moving target. The gun fires by itself at random times. The player has to point the gun in a fixed direction, and the target moves from side to side with a constant frequency.



At which region should the player take a fixed aim in order to score the greatest number of hits?

(A) 3

(B) Either 1 or 5

(C) Either 2 or 4

(D) Any of 1, 2, 3, 4 and 5

8. A wave source of frequency 1000 Hz emits waves of wavelength 0.10 m. How long does it take for the waves to travel 2500 m?

(A) 2.5 s (B) 4.0 s

(C) 25 s (D) 100 s

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3.2
LIGHT

3.2 (a) Reflection of light

3.2 (b) Refraction of light

3.2 (c) Thin converging lens

3.2 (d) Dispersion of light

3.2 (e) Electromagnetic spectrum

Learning Outcomes

Candidates should be able to:

3.2 (a) Reflection of light

Core

- Describe the formation of an optical image by a plane mirror, and give its characteristics
- Use the law *angle of incidence = angle of reflection*

Supplement

- Perform simple constructions, measurements and calculations

3.2 (b) Refraction of light

Core

- Describe an experimental demonstration of the refraction of light
- Use the terminology for the angle of incidence *i* and angle of refraction *r* and describe the passage of light through parallel-sided transparent material
- Give the meaning of critical angle
- Describe internal and total internal reflection

Supplement

- Recall and use the definition of refractive index *n* in terms of speed
- Recall and use the equation $\sin i / \sin r = n$
- Describe the action of optical fibres particularly in medicine and communications technology

3.2 (c) Thin converging lens

Core

- Describe the action of a thin converging lens on a beam of light
- Use the terms principal focus and focal length
- Draw ray diagrams to illustrate the formation of a real image by a single lens

Supplement

- Draw ray diagrams to illustrate the formation of a virtual image by a single lens
- Use and describe the use of a single lens as a magnifying glass

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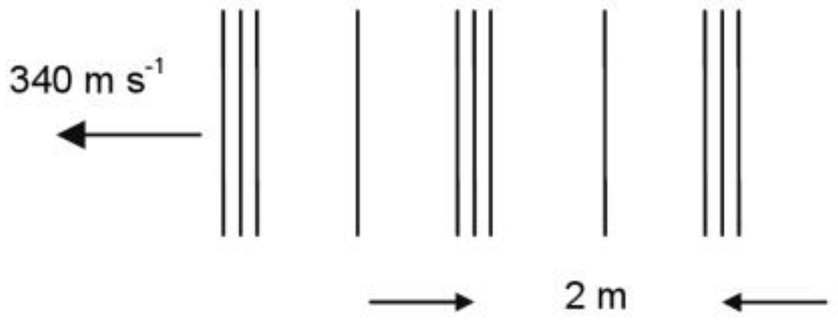
3.3.2 Speed of sound

MCQs

1. A sound wave traveling at 340 m/s produces the waveform shown below



What is the frequency of the sound wave?

(A) 85 Hz (B) 170 Hz

(C) 340 Hz (D) 680 Hz

2. A boy stands in front of a cliff. He claps his hands so that every clap coincides with the echo of his previous clap. He discovers that he claps his hands every 0.8s. The velocity of sound in air is 340 m s^{-1}. What is the separation between the cliff and the boy?

(A) 136 m (B) 272 m

(C) 425 m (D) 850 m

3. A sonic 'tape measure' is used to measure the length of a room. It measures a time interval of 0.060 s between transmitting a sound pulse and receiving the echo. The speed of sound in air is 330 m/s. How far is the reflecting wall from the 'tape measure'?

(A) 5.5 m (B) 9.9 m

(C) 11 m (D) 20 m

Questions – 3.3.2

1. Study the information given below and answer the questions at the end of it.

A student measures the speed of sound in a laboratory. Instead of using a stopwatch and a metre rule, he chooses to an arrangement as shown in Figure 1.1 below.

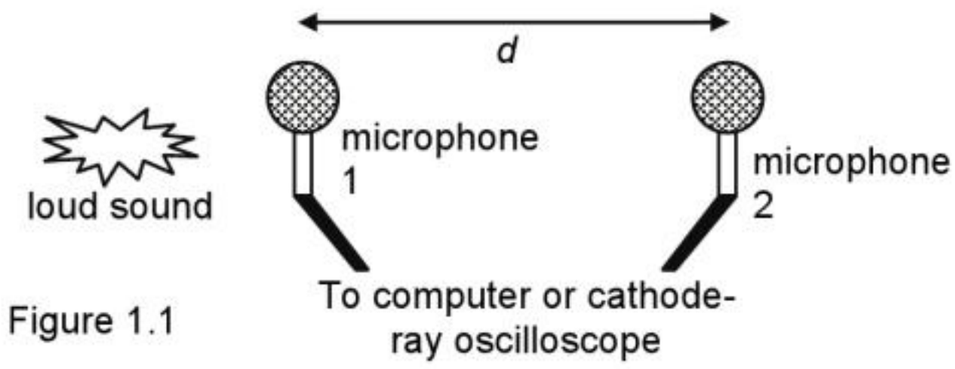


Figure 1.1

The sound is received by two microphones placed a distance *d* apart. The time interval *t* between the sound arriving at microphone 1 and microphone 2 is recorded. The signals from the microphones are fed into a computer which displays the value of *t*. Figure 1.2 shows the average values for *t* as *d* is varied.

d /m	1.000	2.000	3.000	4.000
t /s	0.0032	0.0060	0.0092	0.0121

Figure 1.2

Figure 1.3 shows the trace obtained when the signals are fed to the two inputs of a cathode ray oscilloscope with a time-base setting of 1.0 ms/cm.

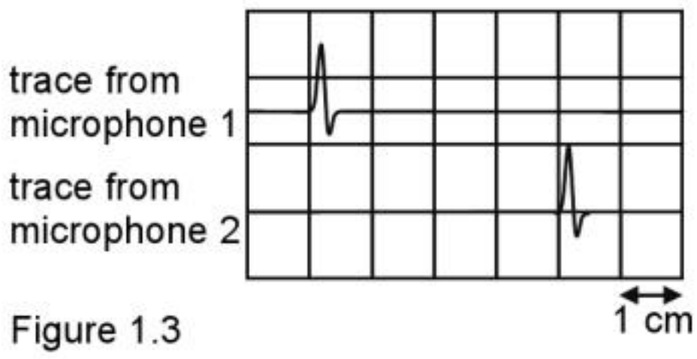


Figure 1.3

The sound waves traveling from microphone 1 to microphone 2 is illustrated in Figure 1.4. Points A, B, C and D are the centres of regions of compression.

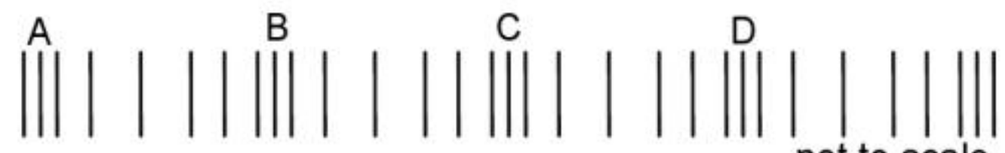


Figure 1.4

(a) Explain why the student decides not to use the stopwatch and metre rule to measure the speed of sound.

(b) Using data from Figure 1.2, determine the speed of sound in air.

(c) From the trace observed on the cathode-ray oscilloscope in Figure 1.3, determine the distance between the 2 microphones.

(d) Describe what happens as one complete sound wave moves past point A, B, C or D in Figure 1.4.

2. How would you use a signal generator and a loudspeaker to show the relationship between the frequency of vibration of a source and the pitch of the sound produced?

In your account, you should

- state the audible frequency of the sound wave from the generator
- draw a diagram of the apparatus
- explain how to use the signal generator to produce different sound.

3.3.3 Echo

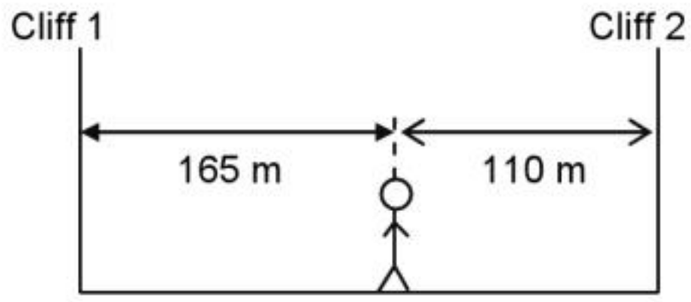
MCQs

1. A sonar on a ship is used to find the depth of the sea. An ultrasonic wave pulse is sent downwards from the ship towards the sea bed. The pulse travels with a speed of 1500 m/s in sea water. If the reflected pulse is received after 1.6 s, find the depth of the sea.

(A) 1200 m (B) 2400 m

(C) 4800 m (D) 4688 m

2. A man stands between two cliffs as shown in the diagram and claps his hands once.

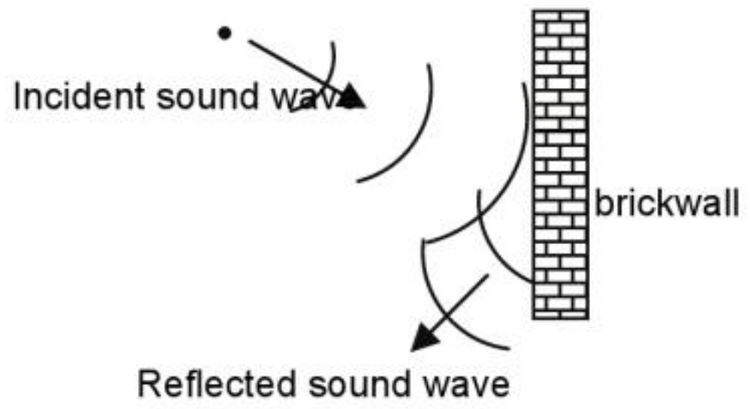


Assuming that the velocity of sound in air is 330 m/s, what will be the time interval between the two loudest echoes?

(A) $\frac{1}{6}$ s (B) $\frac{1}{3}$ s

(C) $\frac{2}{3}$ s (D) $\frac{5}{6}$ s

3. A sound wave is reflected from a brick wall.



Compared with the incident wave, the reflected wave has

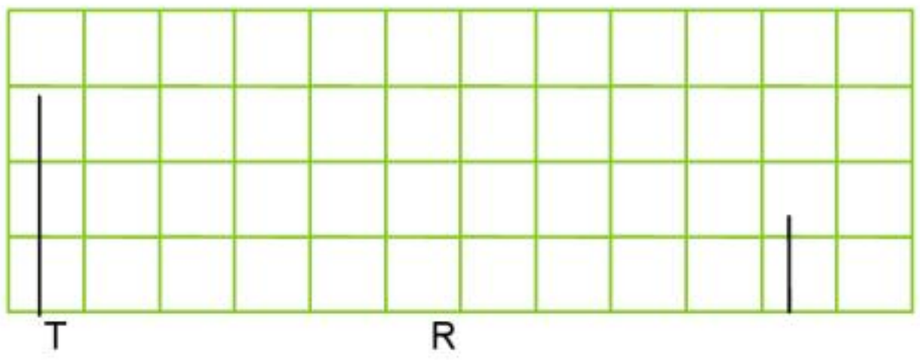
(A) a greater amplitude

(B) a shorter wavelength

(C) the same speed

(D) the same velocity

4. A radio pulse is transmitted vertically upwards to measure the height of the ionosphere. The outgoing pulse T, and its reflection R from the ionosphere, are recorded on the screen of an oscilloscope with time-base set at 50 μs per division.

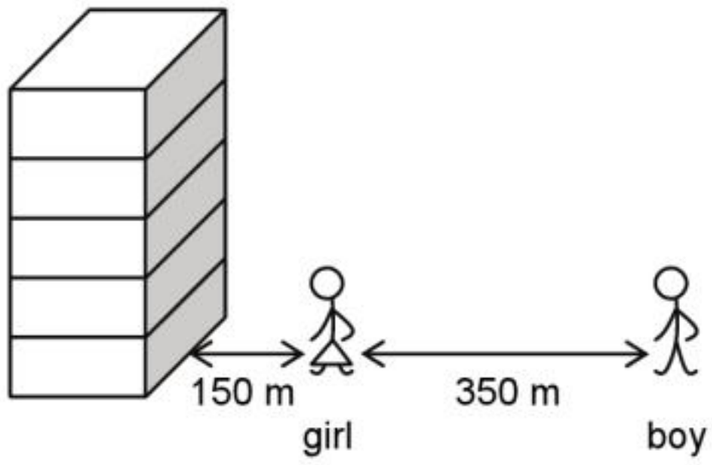


If the speed of radio pulse in air is 3×10^8 m s^{-1}, what is the approximate height of the ionosphere?

(A) 6.5 km (B) 13 km

(C) 15 km (D) 75 km

5. A girl, standing 150 m in front of a tall building, fires a shot with a starting pistol. A boy, standing 350 m behind her, hears two bangs 1 s apart.



From this information, what is the speed of sound in air?

(A) 150 m s^{-1} (B) 300 m s^{-1}

(C) 350 m s^{-1} (D) 500 m s^{-1}

6. A marine survey ship sends a sound wave straight to the sea bed. It receives an echo 1.5 s later. The speed of sound in sea-water is 1500 m s^{-1}. How deep is the sea at this position?

(A) 500 m (B) 1000 m

(C) 1125 m (D) 2250 m

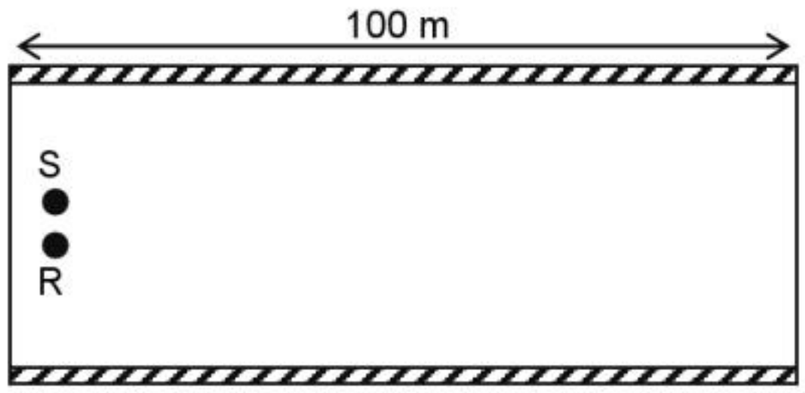
7. The echo sounder of a ship indicates the depth of the water below the keel to be 480 m. If the time interval for the sounding is estimated to be $\frac{1}{5}$ s, the speed of sound in water would be approximately

(A) 1 200 m s^{-1} (B) 2 400 m s^{-1}

(C) 3 600 m s^{-1} (D) 4 800 m s^{-1}

Questions – 3.3.3

1. The diagram below shows the plan of a very large hall, 100 m long, which has sound-absorbent side walls and a smooth hard wall at each end.



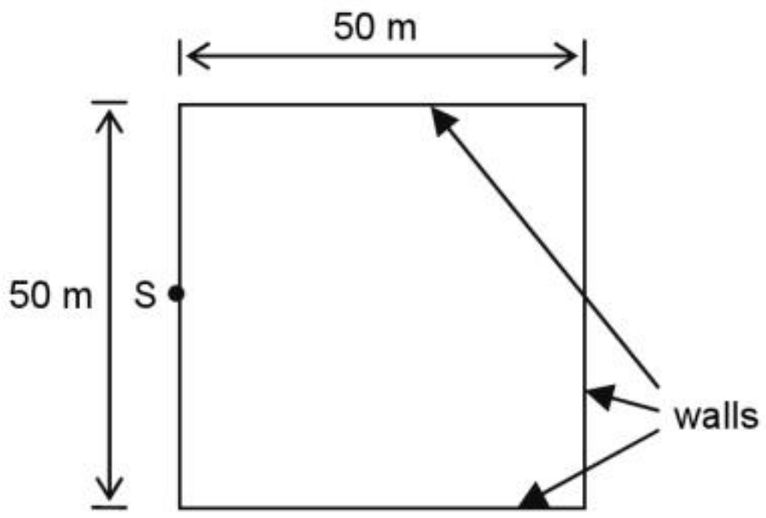
A source of sound at S emits a short single blast.

(a) Why are several echoes of decreasing loudness heard by an observer at R?

(b) Calculate the approximate time interval between the second and third echoes heard at R, given that the speed of sound in air is 340 m/s.

(c) Suggest how to improve on the accuracy of the distance calculated in (b).

2. A sound source is set at S in the centre of one wall of a quadrangle, as shown in the diagram.



(a) Draw the path of the sound wave returning to S after striking each of the other three walls in turn.

(b) State with two reasons why the loudness of the sound returning to S is less than that of the sound leaving S.

3. A group of geologists are in the search of oil and they cause small explosion at the surface of Earth when a possibility arises at a particular location. In an exploration, 3.2 s is recorded between the explosion and the echo from possible oil-bearing rocks. Given the speed of sound through the Earth is 1800 m s^{-1}.

(a) How is the echo produced?

(b) Find the distance of the rocks from the surface of the Earth.

3.3.4 Ultrasound

MCQs

1. What is the approximate range of audible frequencies for a young person?

(A) 2 Hz to 2000 Hz

(B) 20 Hz to 2000 Hz

(C) 20 Hz to 20 000 Hz

(D) 200 Hz to 200 000 Hz

Questions – 3.3.4

1. (a) Describe what is meant by the term ultrasonic waves.

(b) Briefly describe one medical use and one industrial use of ultrasonic waves.

Answer keys:

3.3.1

MCQs

1. C
2. D
3. D
4. D
5. D
6. A
7. C
8. D
9. C
10. C
11. D
12. B
13. A
14. B

Questions

2. (b)(i) 340 m s^{-1}

   (b)(ii) 40 waves

   (b)(iii) higher pitch

3.3.2

MCQs

1. B
2. A
3. B

Questions

1. (b) 326 ms^{-1}

   (c) 1.6 m

3.3.3

MCQs

1. A
2. B
3. C
4. D
5. B
6. C
7. D

Questions

1. 0.59 s
3. (b) 2880 m

3.3.4

MCQs

1. C

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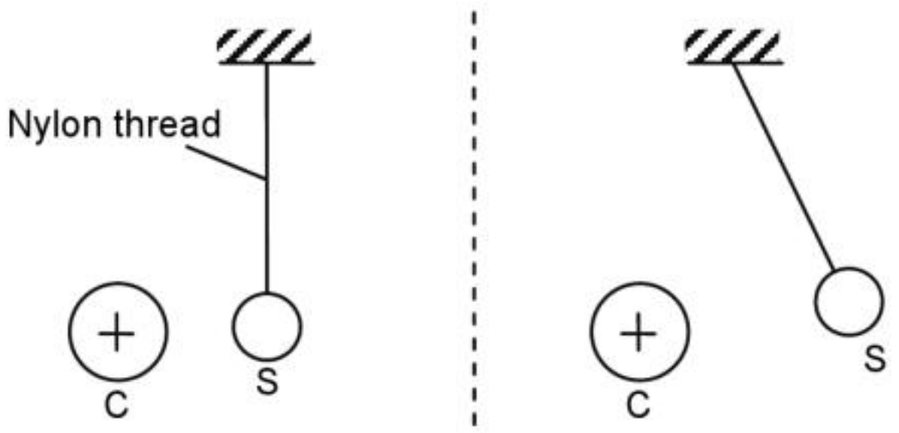
Questions – 4.2(a).2

1. An electrically charged sphere C is brought near a small uncharged conducting sphere S suspended as shown in the figure below (left). S is first attracted towards C until it touches the surface of C and then repelled to the position shown in the next figure (right).



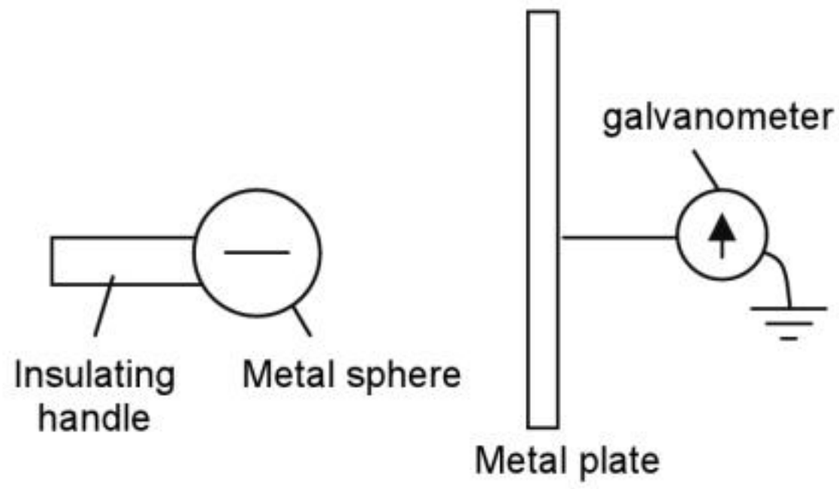
(a) (i) Explain carefully why S is first attracted towards C.

(ii) Explain why S is repelled after touching the surface of C.

(b) On the figure (right), mark and label each force acting on S.

(c) When a bunsen flame is passed beneath S, the sphere falls back towards C. Suggest why this happens.

2. The figure below shows a negatively charged metal sphere held with an insulating handle. When the sphere is brought towards the metal plate, the very sensitive galvanometer indicates a momentary current.



(a) Why is a momentary current produced?

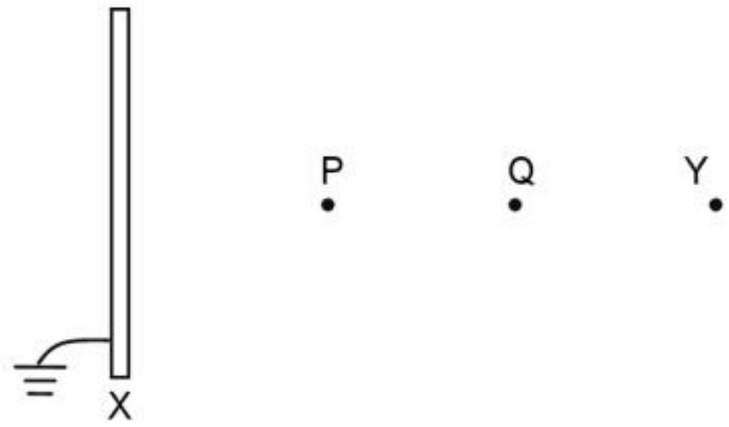
(b) How could a deflection of the galvanometer pointer in the opposite direction be produced?

(c) Why is there no deflection of the galvanometer pointer if the metal sphere is held in the hand and moved towards the metal plate?

4.2(a).3 Electric field

MCQs

1. A point charge is placed at Y in front of an earthed metal sheet X. P and Q are two points between X and Y as shown in the diagram.

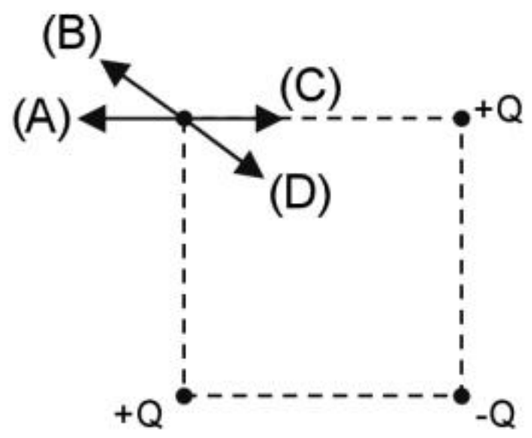


If the electric field strengths at P and Q are respectively E_P and E_Q, which one of the following statements is correct?

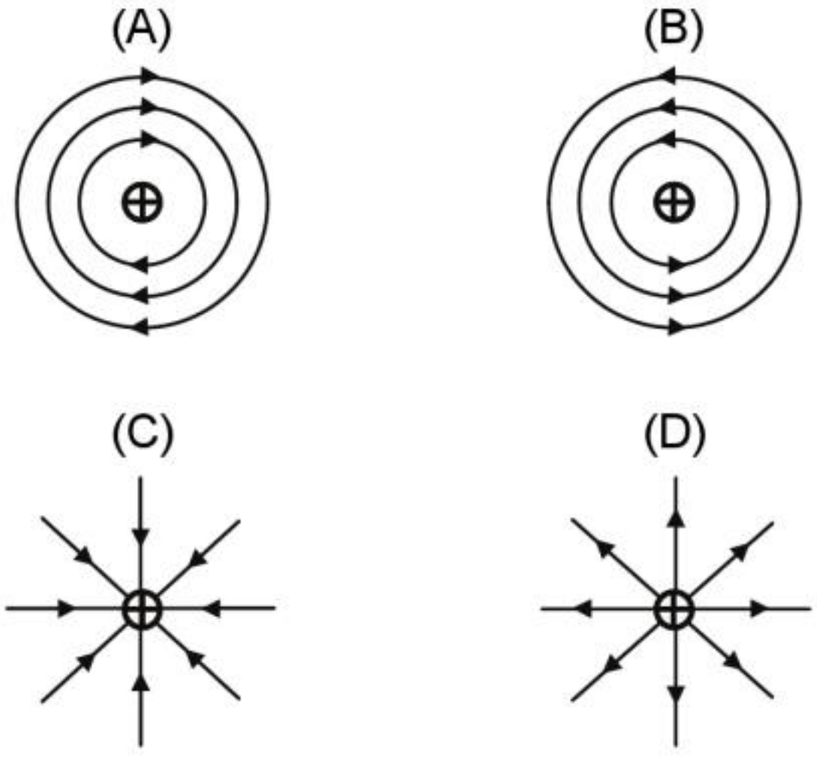
(A) $E_P = E_Q$ (B) $E_P = 0$

(C) $E_P > E_Q$ (D) $E_Q > E_P$

2. Point charges, each of magnitude Q, are placed at three corners of a square as shown in the diagram. What is the direction of the resultant electric field at the fourth corner?

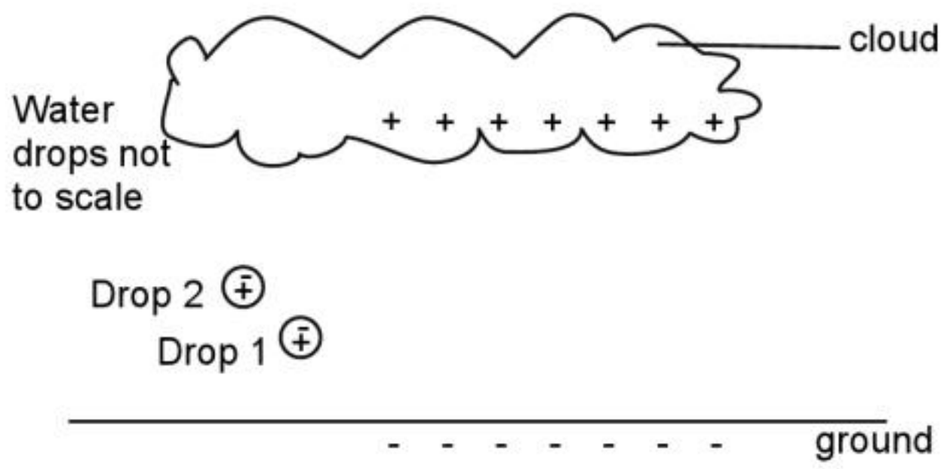


3. Which diagram best illustrates the electric field around a positive point charge?



Questions – 4.2(a).3

1. Thunderclouds contain charges. Water drops are carried up by air currents and become charged. The figure below shows a positively charged cloud and two drops of water.



(a) Draw lines of force to show the electric field between the cloud and the ground. You may ignore the drops.

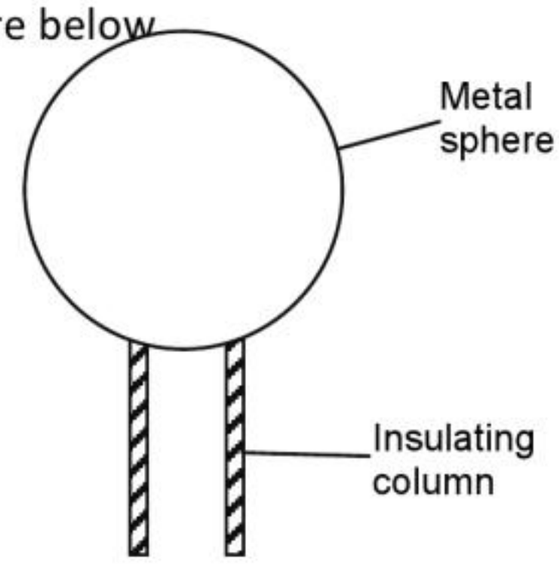
(b) The figure shows the charge distribution on the two drops when they are in the electric field between the cloud and the ground. Drop 1 moves upwards and briefly touches drop 2.

(i) Explain what happens to the charges on the two drops as they touch.

(ii) Having touched, the drops now separate. State what charges will now be found on drop 1 and on drop 2.

(d) The build-up of charge on the cloud causes a large potential difference between the cloud and the ground. Explain, in terms of energy, what is meant by potential difference.

2. In a particular experiment, a high voltage is created by charging an isolated metal sphere, as illustrated in the figure below

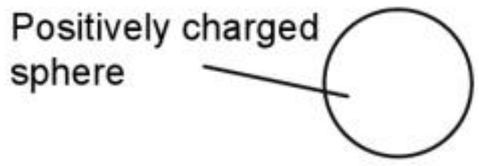


The air surrounding the sphere loses its insulating properties, causing a spark, when the electric field exceeds a certain potential.

(a) By reference to an atom in the air, suggest the mechanism by which the electric field causes the air to become conducting.

(b) Under certain conditions, a spark sometimes occurs before the potential reaches the theoretical value. Suggest a reason for this.

3. The figure below shows a positively charged metal sphere.



As the sphere is moved closer to the earthed plate, the plate becomes negatively charged.

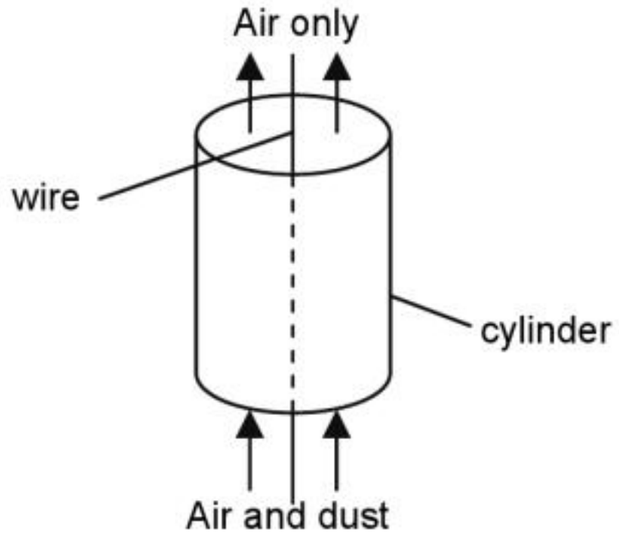
(a) Suggest how the negative charge on the earthed plate arises.

(b) On the figure, draw lines to represent the electric field between the sphere and the plate.

4.2(a).4 Applications of electrostatics

MCQs

1. Dust particles may be extracted from air using the electric field between a wire and a metal cylinder.

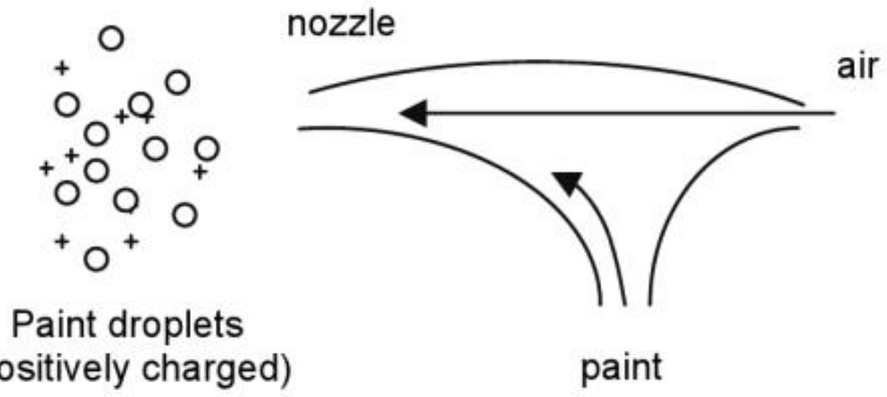


The electric field removes electrons from some air molecules, thus forming ions. These ions then become attached to dust particles. The charged dust particles then move to the inside of the cylinder. Which combination of ion charge and potentials must apply?

	Ion charge	Wire potential	Cylinder potential
(A)	Positive	+10 kV	0
(B)	Positive	0	+10 kV
(C)	Negative	0	+10 kV
(D)	Negative	+10 kV	0

Questions – 4.2(a).4

1. When sprays are used to paint the metal car body panels, the result is sometimes patchy, with some areas being missed. One way to overcome this problem is to use 'electrostatic spraying' as shown in the figure below.



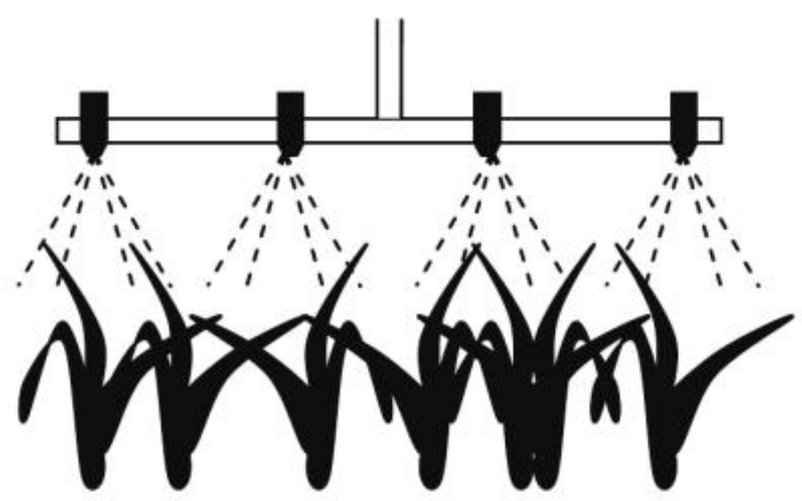
(a) (i) Explain why the droplets spread out as they leave the nozzle.

(ii) Explain why it is important that the metal panel has a negative charge.

(b) State one advantage of using electrostatics in this way to paint the metal panel.

(c) Suggest how the paint droplets become positively charged upon leaving the nozzle.

2. When plants are sprayed with insecticide, the spray droplets are given a positive charge by a spray gun.



(a) How did the drops of insecticide acquire the positive charge?

(b) Small amounts of charge can move about in the plants. What type of charge will be attracted to the surface of the leaves as the insecticide is sprayed onto the plants?

(c) Give two advantages of using charged insecticide droplets. Explain your answer for one of the advantage you give.

Answer keys:

4.2(a).1

MCQs

1. None of the answers
2. C
3. C
4. A
5. C
6. C
7. B

4.2(a).2

MCQs

1. C
2. A
3. C

4.2(a).3

MCQs

1. D
2. B
3. D

4.2(a).4

MCQs

1. A

4.2(b) Current

MCQs

1. 40 J of energy was withdrawn from a battery as it was used for 20 s. If the e.m.f. of the battery was 2.0 V, how much of electrical charge was withdrawn during that time period?

(A) 80 C (B) 20 C
(C) 2 C (D) 0.1 C

2. Which one of the following correctly names two types of conductor in both of which the motion of positive ions contributes to the transfer of charge?

(A) metals and liquid electrolytes
(B) liquid electrolytes and ionised gases
(C) metals and ionised gases
(D) n-type semiconductors and metals

3. Consider the following passage, which contains an error.

'In POOR conductors ELECTRICAL energy is transferred by lattice VIBRATIONS. These travel through the specimen as waves which are SCATTERED by the lattice as they progress through it.'

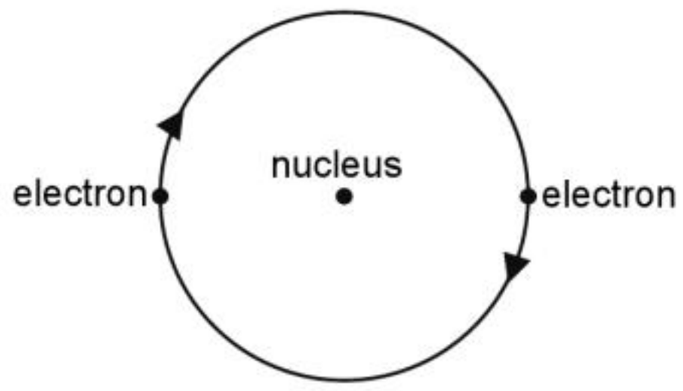
What is the error?

(A) POOR should be METALLIC.
(B) ELECTRICAL should be THERMAL.
(C) VIBRATIONS should be IMPERFECTIONS.
(D) SCATTERED should be REFRACTED.

4. Mains electrical equipment is sometimes provided with a neon indicator lamp to show when the equipment is switched on. What charge carriers convey the current in the neon?

(A) electrons only
(B) positive ions only
(C) negative ions only
(D) positive ions and electrons

5. The diagram shows a model of an atom I which two electrons move round a circular orbit. The electrons complete one full orbit in 1.0×10^{-15} s.

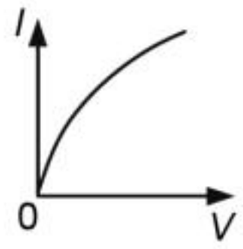


What is the current caused by the motion of the electrons in the orbit?

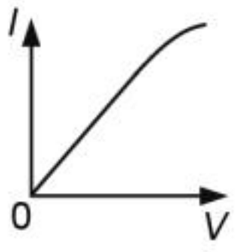
(A) 1.6×10^{-34} A
(B) 3.2×10^{-34} A
(C) 1.6×10^{-4} A
(D) 3.2×10^{-4} A

Which graph represents the variation of I, the current through the lamp, with the potential difference V across it?

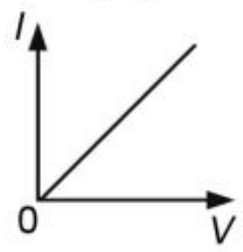
(A)



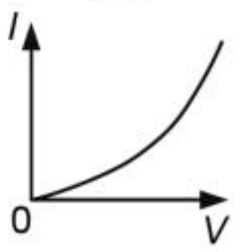
(B)



(C)

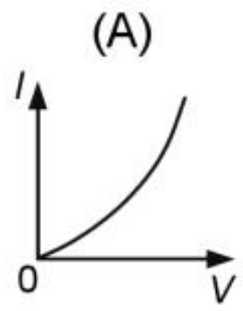


(D)

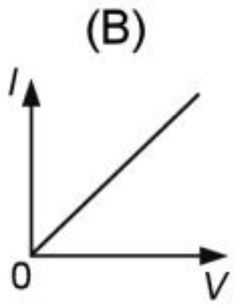


10. Which graph best represents the way in which the current *I* through a thermistor depends upon the potential difference *V* across it?

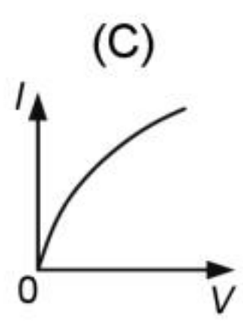
(A)



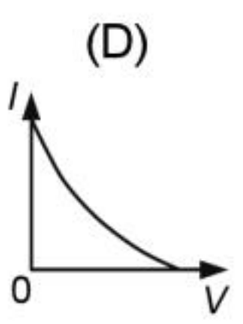
(B)



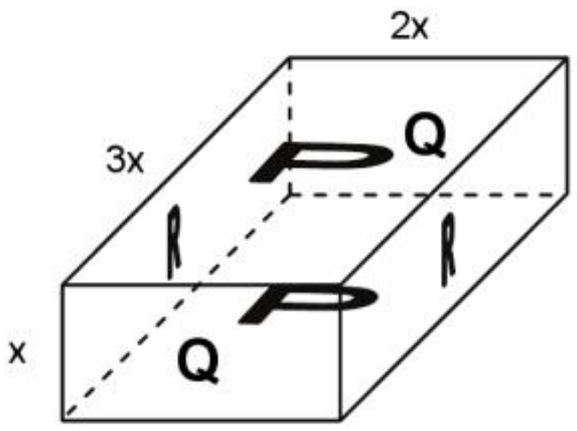
(C)



(D)



11. The diagram shows a rectangular block with dimensions x, 2x and 3x.



Electrical contact can be made to the block between opposite pairs of faces (for examples, between the faces labeled P).

Between which two faces would the maximum electrical resistance be obtained?

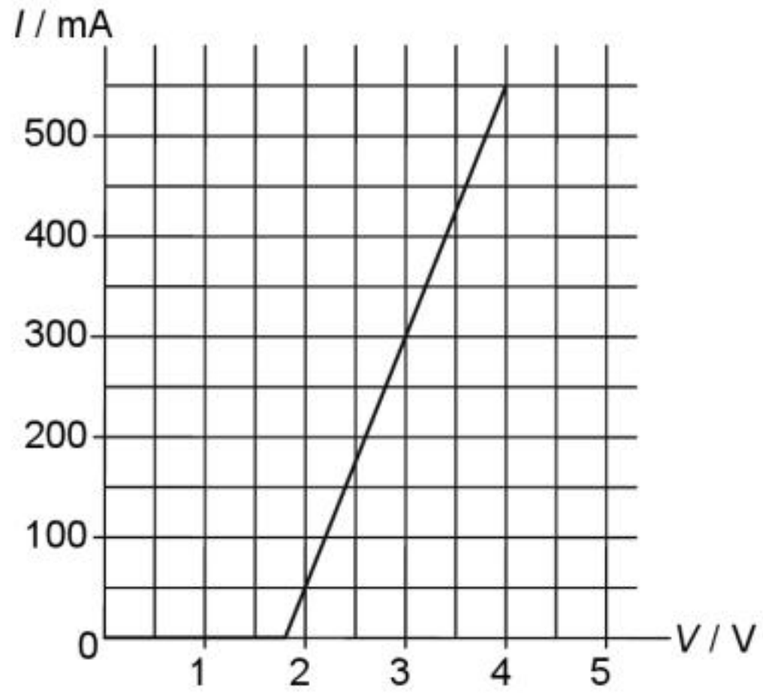
(A) the faces labeled P

(B) the faces labeled Q

(C) the faces labeled R

(D) the resistance is the same, whichever pair of faces is used

12. The diagram shows the relation between the direct current *I* in a certain conductor and the potential difference *V* across it. When $V < 1.8$ V, the current is negligible.



Which statement about the conductor is correct?

(A) It does not obey Ohm's law but when $V > 1.8$ V its resistance is 4 Ω.

(B) It does not obey Ohm's law but when $V = 3$ V its resistance is 10 Ω.

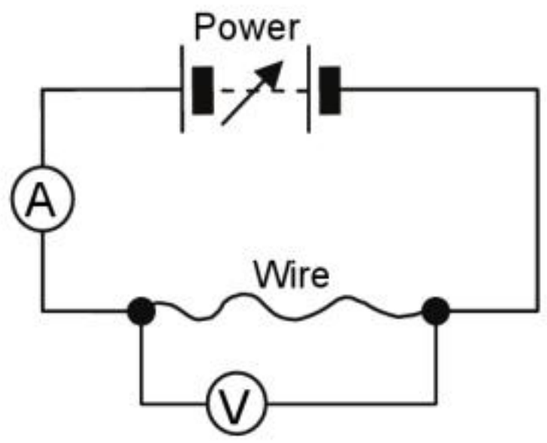
(C) It obeys Ohm's law when $V > 1.8$ V and when $V = 3$ V its resistance is 10 Ω.

(D) It obeys Ohm's law when $V > 1.8$ V but its resistance is not constant.

Questions – 4.2(e)

1. In a Physics book a student reads that the resistance of a piece of wire depends upon its cross-sectional area, its length and the material of which it is made.

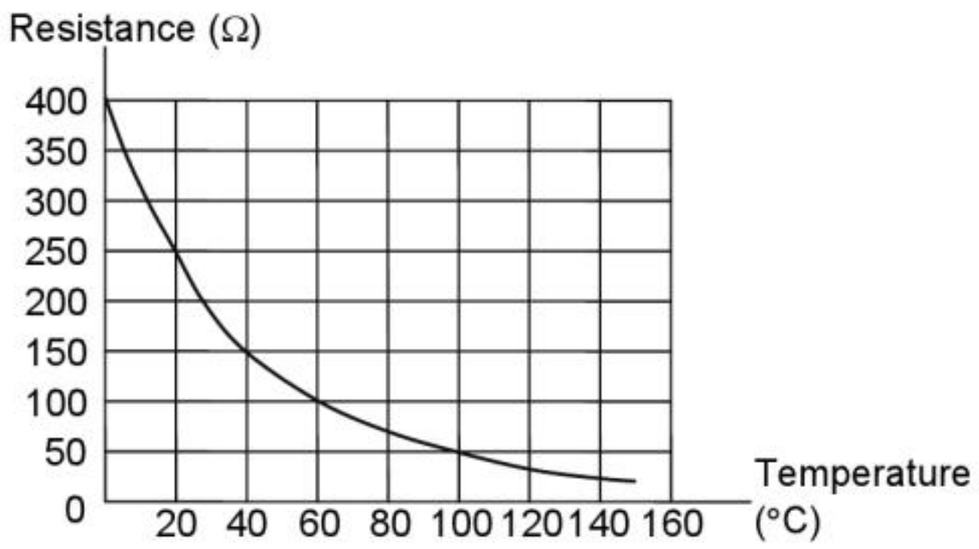
The student decides to examine how the cross-sectional area of a piece of wire affects its resistance in the laboratory using the circuit diagram shown in figure 8. He selects 3 pieces of nichrome wire, each 1 m long and of cross-sectional areas 0.25 mm^2, 0.4 mm^2 and 0.75 mm^2.



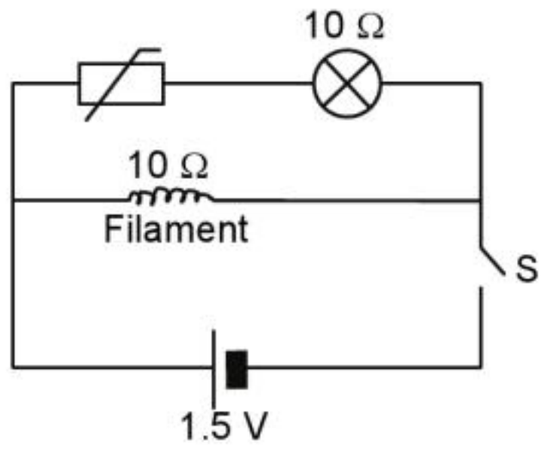
(a) Describe how would he determine the cross-sectional area of the wires accurately?

(b) Sketch a graph of voltage V against current I.

2. The graph in the figure below shows how the resistance of a thermistor changes with temperature.



A student then sets up the circuit in the figure below. The heating filament is mounted close to the thermistor.



(a) When switch S is closed, the lamp failed to light up at first but does so at a later time. Explain.

(b) If the lamp barely lights up when a current of 13.6 mA flows through it, what is the minimum temperature that the lamp will light up? Show your working clearly.

3. Sketch graphs with labeled axes to show how the current through the wire will vary with the p.d. across it if the temperature of the wire

(a) is kept constant.

(b) increases as the current increases.

4. A copper wire of length 1.5 m and diameter 1.2×10^{-4} m has a resistance of 2.0 Ω. Determine the resistance of copper wires

(a) of length 2.5 m and diameter 1.2×10^{-4} m,

(b) of length 1.5 m and diameter 2.4×10^{-4} m.

4.2(f) Electrical energy

Questions treated in 4.4.

Answer keys:

4.2(b)

MCQs

1. B
2. B
3. B
4. A
5. D

4.2(c)

MCQs

1. B
2. A

4.2(d)

MCQs

1. B
2. C
3. B
4. A

4.2(e)

MCQs

1. B
2. A
3. B
4. C
5. D
6. A
7. A
8. C
9. A
10. A
11. B
12. A

Questions

2. (b) 60 °C
4. (a) 3.3 Ω

   (b) 0.5 Ω

4.3 ELECTRIC CIRCUITS

4.3(a) Circuit diagrams

4.3(b) Series & parallel circuits

1 Series & parallel circuits

2 Potential divider circuits

3 Thermistor & light-dependent resistor

4.3(c) Action & use of circuit components

4.3(d) Digital electronics

Learning Outcomes

Candidates should be able to:

4.3 (a) Circuit diagrams

Core

- Draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), lamps, ammeters, voltmeters, magnetising coils, transformers, bells, fuses and relays

Supplement

- Draw and interpret circuit diagrams containing diodes and transistors

4.3 (b) Series and parallel circuits

Core

- Understand that the current at every point in a series circuit is the same
- Give the combined resistance of two or more resistors in series
- State that, for a parallel circuit, the current from the source is larger than the current in each branch
- State that the combined resistance of two resistors in parallel is less than that of either resistor by itself
- State the advantages of connecting lamps in parallel in a lighting circuit

Supplement

- Recall and use the fact that the sum of the p.d.s across the components in a series circuit is equal to the total p.d. across the supply
- Recall and use the fact that the current from the source is the sum of the currents in the separate branches of a parallel circuit
- Calculate the effective resistance of two resistors in parallel

4.3 (c) Action and use of circuit components

Core

- Describe the action of a variable potential divider (potentiometer)
- Describe the action of thermistors and light dependent resistors and show understanding of their use as input transducers
- Describe the action of a capacitor as an energy store and show understanding of its use in time delay circuits
- Describe the action of a relay and show understanding of its use in switching circuits

Supplement

- Describe the action of a diode and show understanding of its use as a rectifier
- Describe the action of a transistor as an electrically operated switch and show understanding of its use in switching circuits
- Recognise and show understanding of circuits operating as light-sensitive switches and temperature-operated alarms (using a relay or a transistor)

4.3 (d) Digital electronics

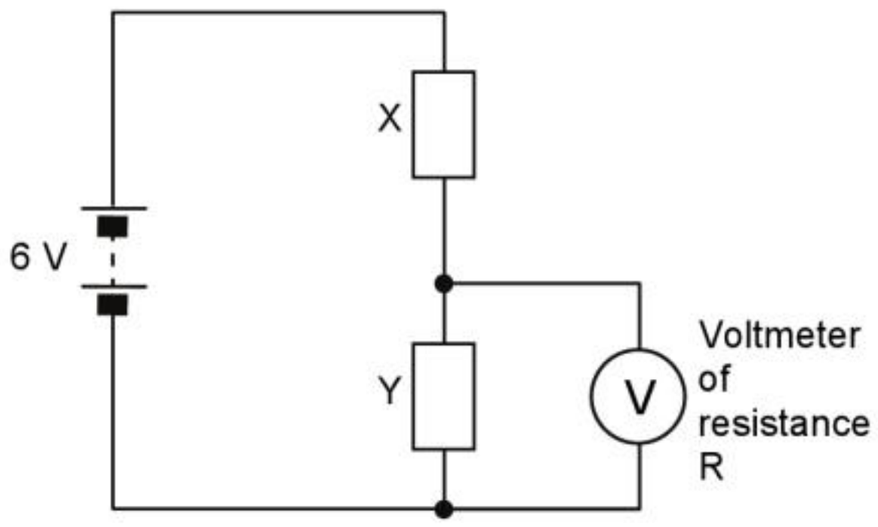
Supplement

- Explain and use the terms digital and analogue
- State that logic gates are circuits containing transistors and other components
- Describe the action of NOT, AND, OR, NAND and NOR gates
- Design and understand simple digital circuits combining several logic gates
- State and use the symbols for logic gates (candidates should use the American ANSI#Y 32.14 symbols)

4.3(b).2 Potential divider circuits

MCQs

1. In the circuit shown, resistors X and Y, each of resistance R, are connected to a 6 V battery of negligible internal resistance. A voltmeter, also of resistance R, is connected across Y.



What is the reading of the voltmeter?

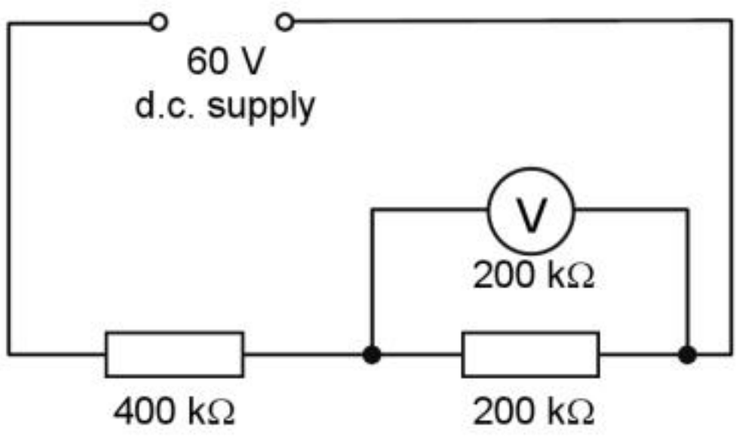
(A) zero

(B) between zero and 3 V

(C) 3 V

(D) Between 3 V and 6 V

2. A constant 60 V d.c. supply is connected across two resistors of resistance 400 kΩ and 200 kΩ

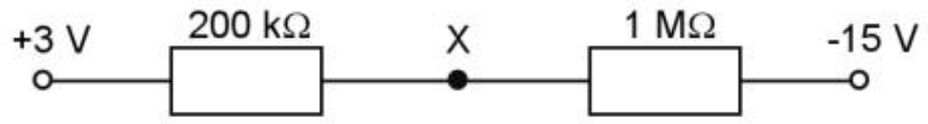


What is the reading of the voltmeter, also of resistance 200 kΩ when connected across the second resistor as shown in the diagram?

(A) 12 V (B) 15 V

(C) 20 V (D) 30 V

3. Two resistors, of resistance 200 kΩ and 1 MΩ respectively, form a potential divider with outer junctions maintained at potentials of +3 V and -15 V.

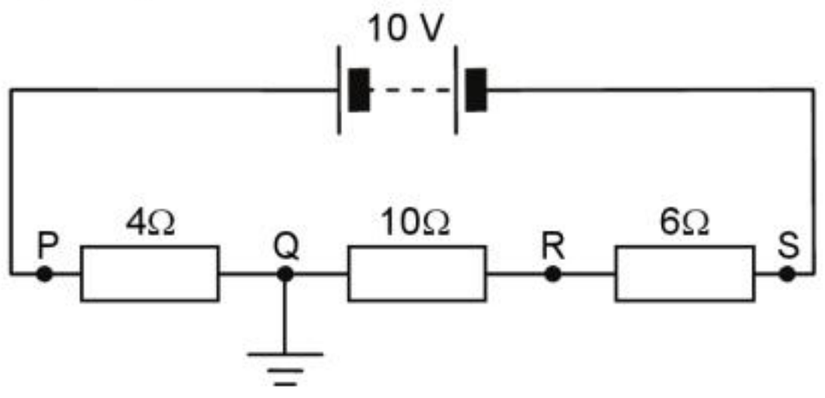


What is the potential at the junction X between the resistors?

(A) +1 V (B) 0 V

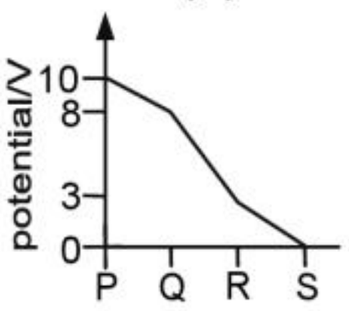
(C) -0.6 V (D) -12 V

4. The diagram shows three resistors of resistances 4Ω, 10Ω and 6Ω connected in series. A potential difference of 10 V is maintained across them, with point Q being earthed.

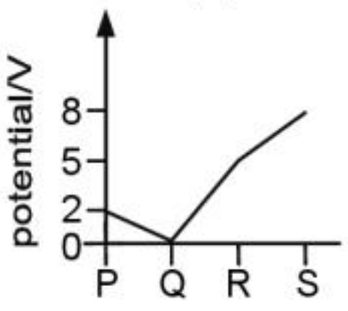


Which graph represents the change in potential along the resistor network?

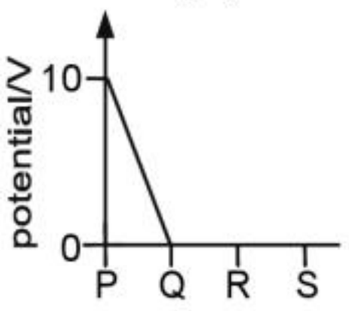
(A)



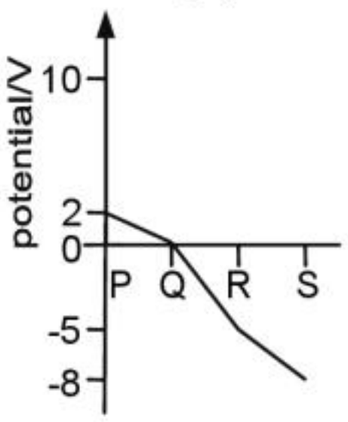
(B)



(C)

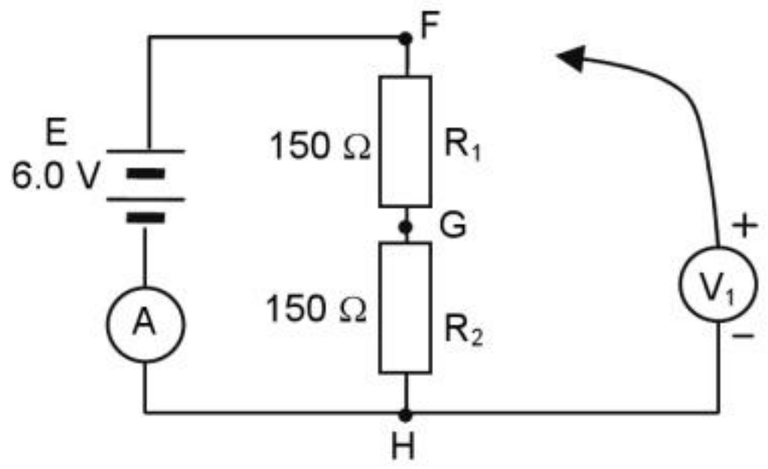


(D)



Questions – 4.3(b).2

1. In the circuit shown below, E is a battery of e.m.f. 6.0 V and negligible internal resistance. R_1 and R_2 are resistors, each of resistance 150 Ω. V_1 is a high resistance voltmeter and A is an ammeter of negligible resistance.



(a) What are the ammeter and voltmeter readings when the positive terminal of the voltmeter is connected to point F?

(b) What are the corresponding ammeter and voltmeter readings when the positive terminal of the voltmeter is connected to first to point G and then to point H?

4.3(b).3 Thermistor & light–dependent resistor

MCQs

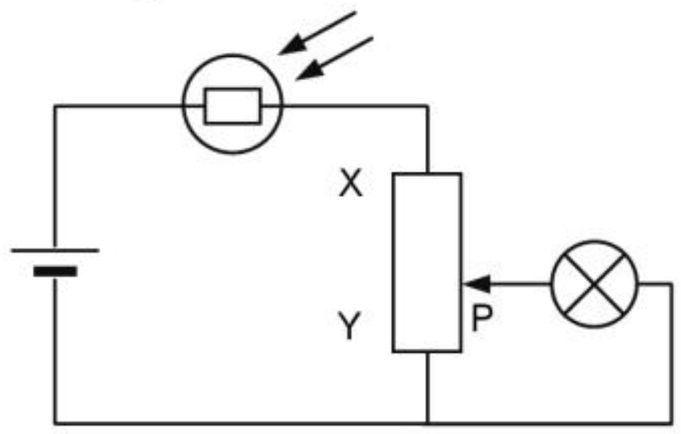
1. Which of the following devices convert(s) electrical energy into light energy?

1. LED
2. LDR
3. Thermistor

(A) 1 only (B) 2 only

(C) 1 and 3 only (D) 2 and 3 only

2. In the circuit shown below, the light bulb will become brighter when



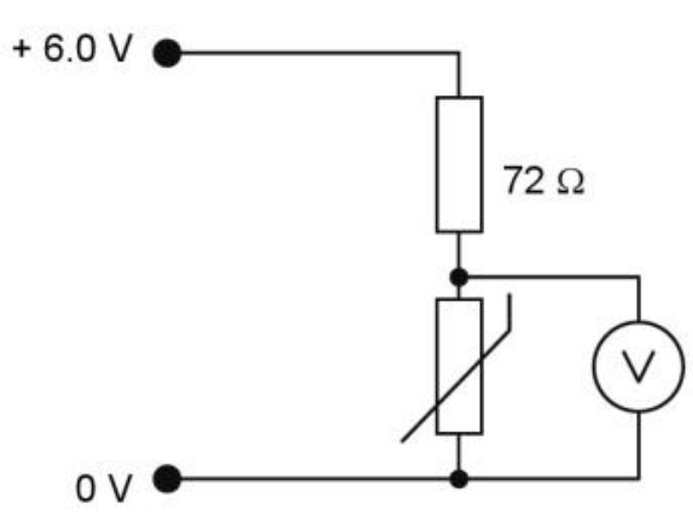
(A) light is incident on the LDR and P is moved to X.

(B) light is incident on the LDR and P is moved to Y.

(C) the LDR is covered and P is moved to X.

(D) the LDR is covered and P is moved to Y.

3. A thermistor is connected in series with a 72 Ω resistor across a 6.0 V power supply. When the temperature of the thermistor is 20 °C, the p.d. across it is 2.0 V.

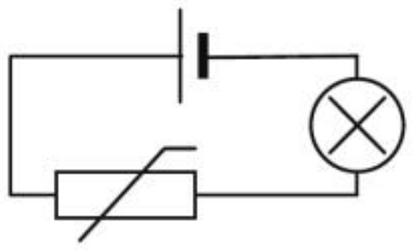


What is the resistance of the thermistor at 20°C?

(A) 36 Ω (B) 48 Ω

(C) 108 Ω (D) 144 Ω

4. The diagram shows a thermistor in a circuit. What happens as the temperature of the surroundings increases?



(A) The light bulb will flash intermittently.

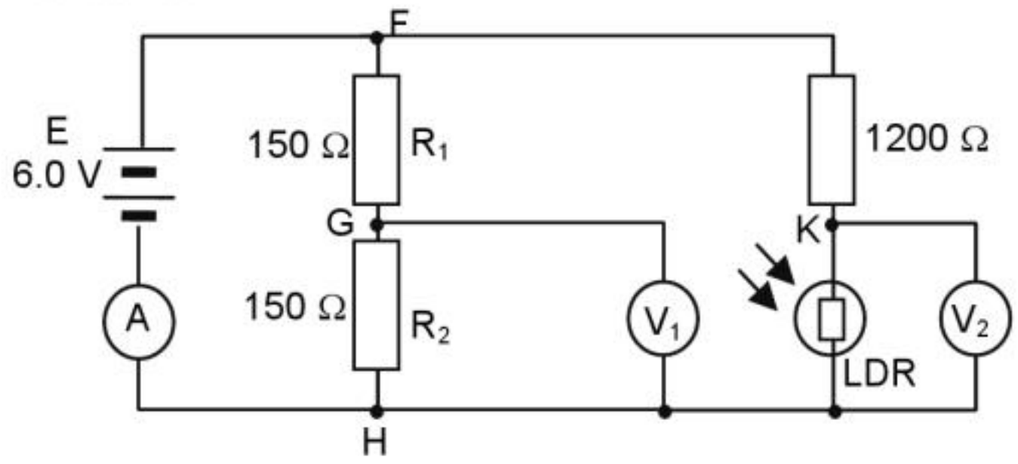
(B) The light bulb will get dimmer.

(C) The light bulb will get brighter.

(D) The light bulb is unaffected.

Questions – 4.3(b).3

1. In the circuit shown below, a light dependent resistor (LDR) is connected in series with a resistor of resistance 1200 Ω. V_1 and V_2 are high resistance voltmeters, and A is an ammeter of negligible resistance.



When no light falls on the LDR, its resistance is 3600 Ω. When the only light falling on the LDR comes from a small filament lamp placed 50 mm away, its resistance is 1200 Ω.

(a) Calculate the readings on A and V_2 when no light falls on the LDR.

(b) Calculate the reading on V_2 when light from the lamp falls on the LDR.

(c) Calculate the reading on a suitable high resistance voltmeter connected to points G and K when light from the lamp falls on the LDR.

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