PASIR RIS CREST SECONDARY SCHOOL
Preliminary Examination
Secondary Four Express

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| CANDIDATE NAME | |

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|---|---|---|---|---|---|---|
| CLASS | | / | | INDEX NUMBER | | |

# Physics

Paper 2

**6091/02**

**20 August 2024**

**1 hour 45 minutes**

Candidates answer on the Question Paper

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

**Section A**
Answer **all** questions.
Write your answers in the spaces provided.

**Section B**
Answer one question.
Write your answers in the spaces provided.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

The total number of marks is given in brackets [ ] at the end of each question or part question.

| **For Examiner's Use** |
|---|
| 80 |
| |
| **Parent's Signature** |

## SECTION A

Answer **all** questions.

**1** An airplane, of mass 250 000 kg, is traveling at an altitude of 12 000 m. The airplane encounters severe air turbulence at t = 40 s and experiences rapid ascents and descents. Fig. 1.1 shows the vertical velocity-time graph for the airplane.

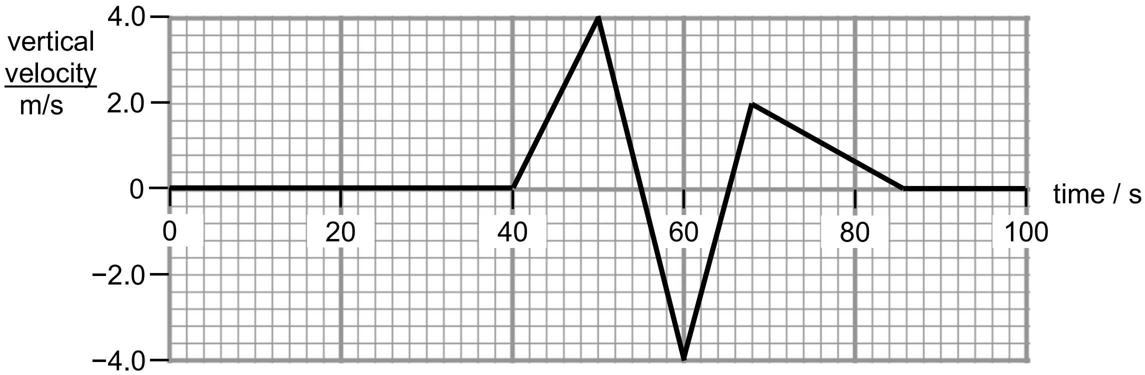


**Fig. 1.1**

**(a)** Describe the vertical forces acting on the airplane at t = 20 s.

…………………………………………………………………………………………………..

………………………………………………………………………………………………….. [2]

.

**(b)** Determine the upward force acting on the airplane at t = 46 s.
The gravitational field strength is 10 N/kg.

upward force = ……………………… [3]

**(c)** Determine the change in the vertical displacement of the airplane from t = 40 s to 85 s.

change in vertical displacement = ……………………… [2]

[Total: 7]

**2** Fig. 2.1 shows a simple hydraulic press.

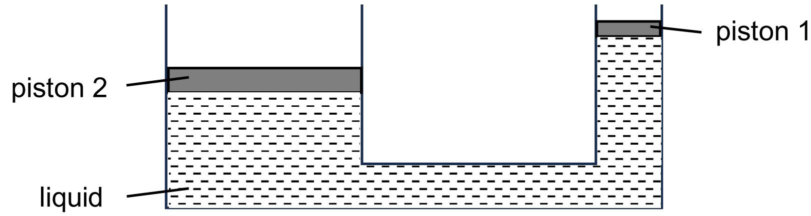


**Fig. 2.1**

A force of 100 N pushes piston 1, which has a cross-sectional area of 10 $cm^2$, downwards by 20 cm. Piston 2, which has a cross-sectional area of 50 $cm^2$, moves upwards as a result.

**(a)** Define pressure.

.......................................................................................................... [1]

**(b)** Calculate

**(i)** the force exerted on piston 2,

force = ........................... [2]

**(ii)** the distance moved by piston 2.

distance = ........................... [2]

**(c)** Explain why the simple hydraulic press does not work if the liquid is replaced by a gas.

..........................................................................................................

.......................................................................................................... [1]

[Total: 6]

**3** Fig. 3.1 shows an unused glass cup with a metal handle.

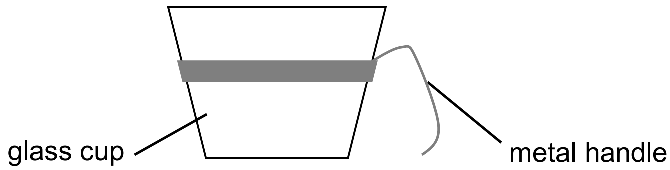


**Fig. 3.1**

A boy touches the glass cup and then the metal handle.

**(a)** Explain why the boy feels that the metal handle is cooler than the glass cup.

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [2]

**(b)** Describe, in microscopic terms, how conduction occurs in within the glass.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [2]

**(c)** 150 g of water at 30 °C is poured into the glass cup. 50 g of ice cubes at –5 °C are then added to the water.

The specific heat capacity of ice is 2.1 J/(g °C).
The specific heat capacity of water is 4.2 J/(g °C).
The specific latent heat of fusion of water is 330 J/g.
Assume all energy transfer is between the water and the ice.

**(i)** On Fig. 3.2, draw a heating curve to show the change in kinetic energy of the particles of the ice cubes till the energy transfer is completed.


**Fig. 3.2**

[1]

**(ii)** Calculate the final temperature of the water.

temperature = ……………………… [3]

[Total: 8]

**4** Ultraviolet light is part of the electromagnetic spectrum.

**(a)** Ultraviolet light enables us to produce vitamin D for our bones, muscles and immune system.

Describe another use of ultraviolet light.

..............................................................................................................

.............................................................................................................. [1]

**(b)** Over-exposure to ultraviolet light can cause heating effects and ionising effects.

Describe the ionising effects on living cells.

..............................................................................................................

..............................................................................................................

..............................................................................................................

.............................................................................................................. [2]

**(c)** The wavelength of ultraviolet light is roughly 100 times larger than the size of an atom.

**(i)** Estimate the wavelength of ultraviolet light.

.............................................................................................................. [1]

**(ii)** Calculate the frequency of the ultraviolet light in **(i)**.
State the value of any constant used.

frequency = ............................ [2]

[Total: 6]

**5** Fig. 5.1 shows an electrostatic precipitator removing dirt particles suspended in the dirty gas.

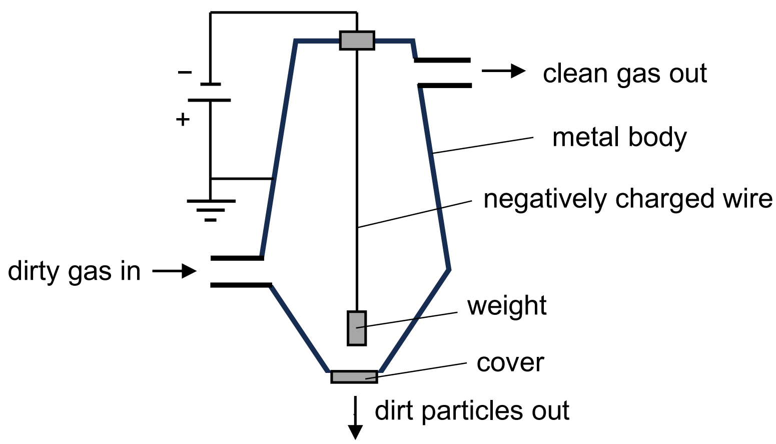


**Fig. 5.1**

**(a)** State the type of charges on the dirt particles after they come into contact with the negatively charged wire.

…………………………………………………………………………………………….. [1]

**(b)** Describe and explain how the charged dirt particles from the dirty gas are removed from the electrostatic precipitator.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………………….. [3]

[Total: 4]

**6** Fig. 6.1 shows a current-carrying solenoid. The directions of current, $I$, entering and leaving the solenoid are shown.

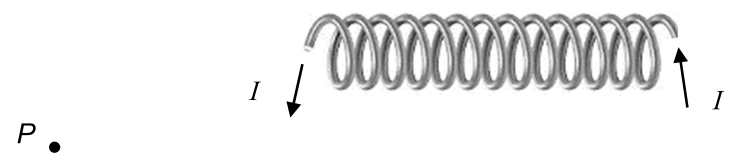


**Fig. 6.1**

**(a)** On Fig. 6.1, draw the magnetic field of the current-carrying solenoid. [1]

**(b)** State the instrument to determine the direction of the magnetic field at point *P*.

………………………………………………………………………………………………….. [1]

**(c)** Some iron nails are placed near but not in contact with the current-carrying solenoid.

Describe and explain, in terms of induced magnetism, what happens to the iron nails.

…………………………………………………………………………………………………..

………………………………………………………………………………………………….. [2]

**(d)** The current flowing to the solenoid is cut off.

Explain what happens to the iron nails.

………………………………………………………………………………………………….. [1]

[Total: 5]

**7** Fig. 7.1 shows a dc motor.

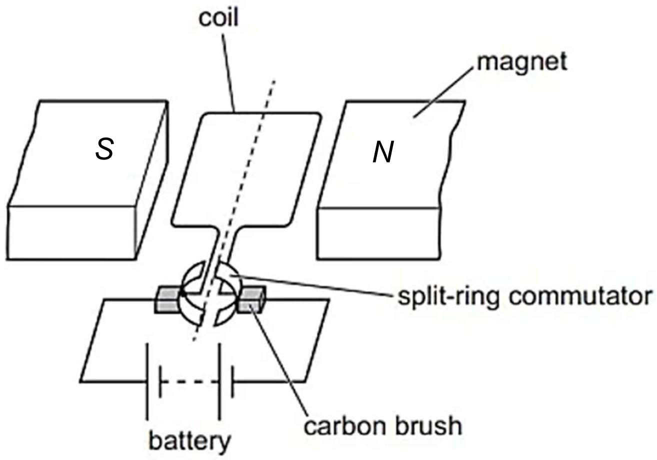


**Fig. 7.1**

**(a)** State the direction of rotation of the coil.

............................................................................................................ [1]

**(b)** Explain why the coil experiences a turning effect.

............................................................................................................

............................................................................................................

............................................................................................................ [2]

**(c)** The turning effect can be increased by adding a soft iron cylinder into the core of the coil.

Explain how the soft iron increases the turning effect.

............................................................................................................

............................................................................................................

............................................................................................................ [2]

**(d)** State how the split-ring commutator ensures the coil rotates in one direction continuously.

............................................................................................................ [1]

[Total: 6]

**8** **(a)** An experiment on electromagnetic induction can be used to show that the direction of the induced current opposes the change producing it.

**(i)** In the space below, draw a labelled diagram using a bar magnet, a solenoid, a galvanometer and connecting wires, to show how this apparatus can be used to investigate electromagnetic induction. [1]

**(ii)** Describe how the experiment shows that the direction of the induced current opposes the change producing it.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

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…………………………………………………………………………………………

………………………………………………………………………………………… [3]

**(b)** Fig. 8.1 shows an a.c. generator.

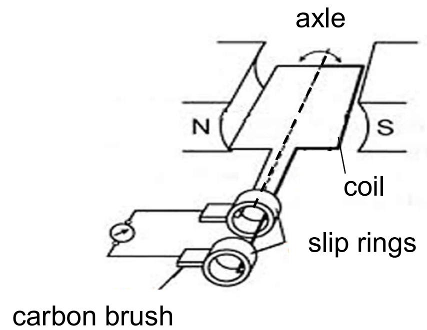



**Fig. 8.1**

**(i)** State why an e.m.f. is induced in the a.c. generator when the coil is rotated.

.................................................................................................... [1]

**(ii)** State one function of the slip rings.

.................................................................................................... [1]

**(iii)** Fig. 8.2 shows how the e.m.f varies with time when the a.c. generator is rotated.

On Fig. 8.2, sketch a graph to show how the e.m.f. changes when the frequency of the rotation of the coil is doubled.

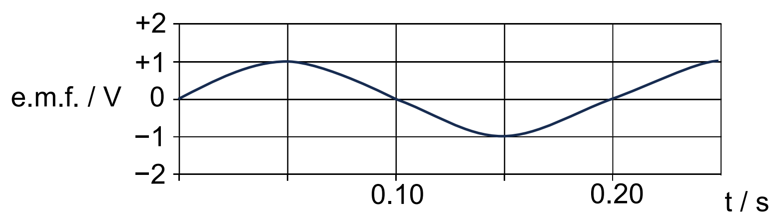



**Fig. 8.2** [2]

[Total: 8]

**9** The shape of a gemstone affects how light is reflected and refracted within the stone.
Fig. 9.1 shows a ray of light ABCD as it enters and leaves a gemstone. Total internal reflections occur at B and at C.

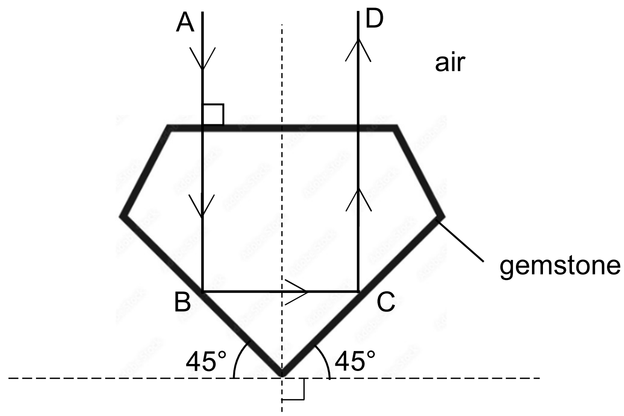



**Fig. 9.1** (not to scale)

Table 9.1 shows the mass, density and refractive index of three gemstones.
One carat is equal to 200 mg.

| gemstone | mass / carat | density / g/cm$^3$ | refractive index |
|---|---|---|---|
| garnet | 3.5 | 7.0 | 2.02 |
| topaz | 2.8 | 3.5 | 1.61 |
| opal | 1.6 | 2.0 | 1.37 |

**Table 9.1**

**(a)** At point B on Fig. 9.1, label the angle of incidence, ***i*** and the angle of reflection ***r***. [1]

**(b)** Explain what is meant by total internal reflection.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

………………………………………………………………………………………………….. [1]

**(c)** Using Table 9.1, determine the gemstone in Fig. 9.1 if its volume is 0.16 cm$^3$.
Show your working.

the gemstone is ………………………………….… [4]

**[Turn over**

**(d)** Fig. 9.2 shows a ray of light enters a piece of diamond which has a critical angle of 24°. The shape of the diamond in Fig. 9.2 is different from the shape of the gemstone in Fig. 9.1.

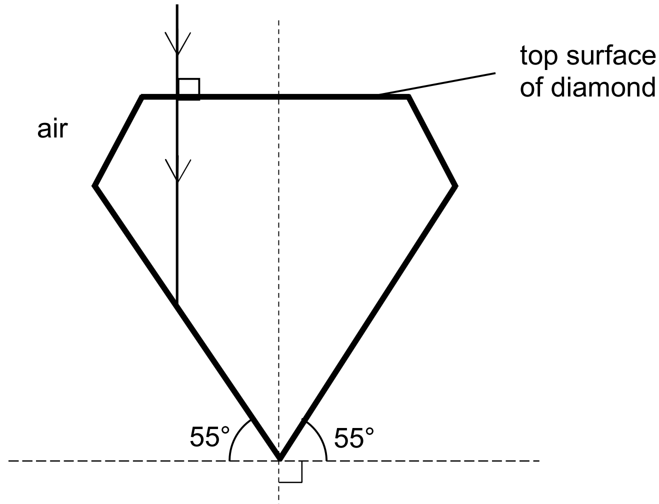



**Fig. 9.2** (not to scale)

**(i)** Explain what is meant by critical angle.

..........................................................................................................

..........................................................................................................

.......................................................................................................... [1]

**(ii)** On Fig. 9.2, draw

1. the path of the ray of light till it leaves the diamond,
2. the normal(s) at the point of incidence within the diamond. [3]

**(iii)** A second diamond is cut to the shape as shown in Fig. 9.1.

Explain why the second diamond is brighter than the diamond shown in Fig. 9.2. when viewed from the top surface.

.......................................................................................................... [1]

[Total: 11]

**10** Fig. 10.1 shows a radiation detector placed in front of a radioactive source in an experiment.

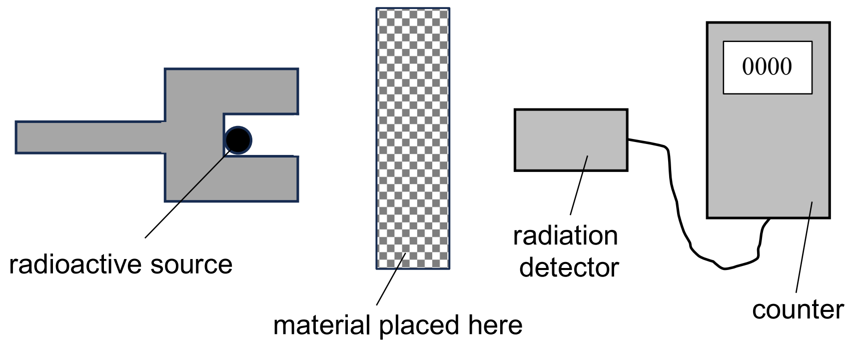



**Fig. 10.1**

Table 10.1 shows the average count rate when different materials are placed between the radioactive source and the radiation detector.

| material | average count rate / counts per minute |
|---|---|
| 3 cm air | 1800 |
| a piece of paper | 1800 |
| 3 mm aluminium | 340 |
| 3 cm lead | 120 |

**Table 10.1**

**(a)** State and explain whether β-particles are emitted by the radioactive source.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

………………………………………………………………………………………………….. [3]

**(b)** Explain why the count rate is not a constant value when identical radioactive source and material is used.

………………………………………………………………………………………………….. [1]

**(c)** State why the radiation detector has an average count rate of 30 counts per minute when the radioactive source is removed.

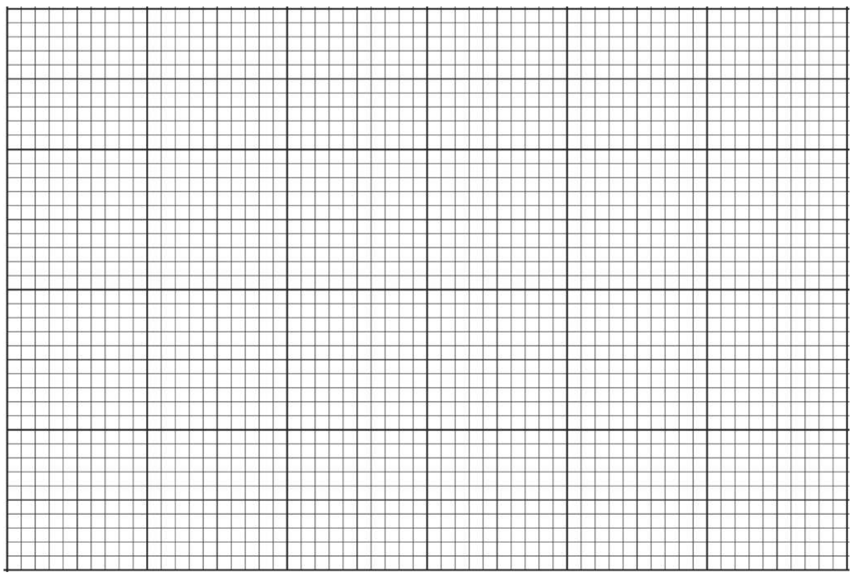
………………………………………………………………………………………………….. [1]

**(d)** The radioactive source has a mass of 64 μg and a half-life of 1600 years.

**(i)** Calculate the time required for the radioactive source to decay to 1 μg.

time = ……………………………………..… [2]

**(ii)** On Fig. 10.2, sketch a graph to show how the mass of the radioactive source changes with time.



[2]

**Fig. 10.2**

[Total: 9]

## SECTION B

Answer **one** question from this section.

**11** **(a)** Fig. 11.1 shows a dry cell of e.m.f. 9.0 V connected to a variable resistor $R_1$, a resistor $R_2$, and a voltmeter.

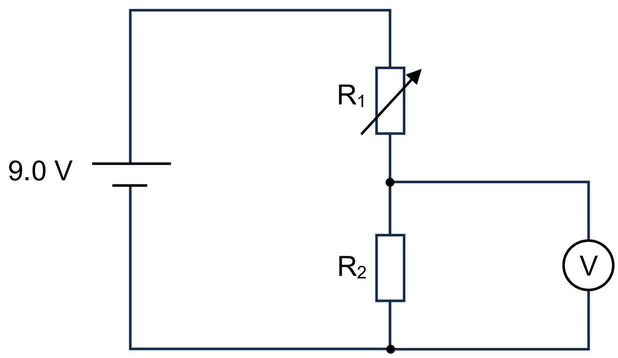



**Fig. 11.1**

When the resistance of $R_1$ increases to 1.0 kΩ, the reading of the voltmeter decreases from 9.0 V to 6.0 V.

**(i)** State the minimum resistance of $R_1$.

minimum resistance = ........................................... [1]

**(ii)** Calculate the resistance of $R_2$.

resistance = ........................................... [2]

**(iii)** In the space below, modify the circuit in Fig. 11.1 and draw a new circuit diagram that will increase the reading of the voltmeter when the environment is dark. [2]

**(b)** Fig. 11.2 shows a filament lamp. It has a thin wire that heats up when an electric current passes through it and produces light as a result.

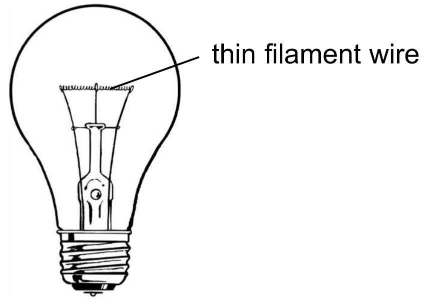



**Fig. 11.2**

The lamp has a rating of 45 W and is connected to the 240 V mains.

**(i)** Explain why the filament wire should be thin.

.................................................................................................... [1]

**(ii)** Calculate the current flowing through the light bulb.

current = ........................................... [2]

**(iii)** The cost of 1 kWh of electrical energy is 30 cents.

Calculate the cost of using 100 such lamps for 2 hours.

cost = ........................................... [2]

[Total: 10]

**12** **(a)** Fig. 12.1 shows a steelyard, which consists of a non-uniform steel rod PS and a scale pan used for weighing.

At the end P, a scale pan is suspended to hold the object whose weight is to be measured. The rod is suspended at Q and a weight of 2.0 N can be placed anywhere between R and S.

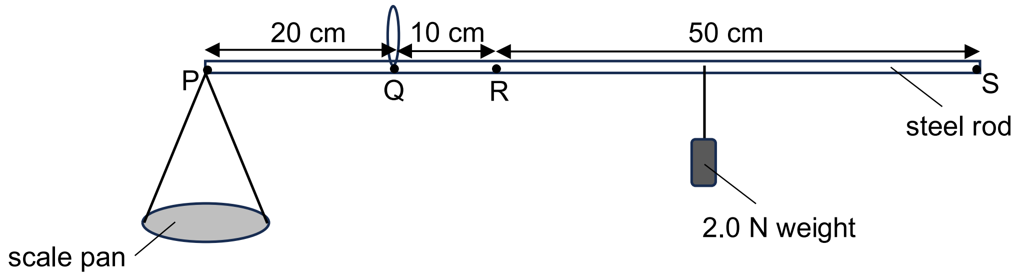



**Fig. 12.1** (not to scale)

When the pan is empty, the 2.0 N weight balances the steelyard at point R.

**(i)** Explain, using the principle of moments, why the weight of the steelyard must be acting between P and Q.

..........................................................................................................

..........................................................................................................

..........................................................................................................

.......................................................................................................... [2]

**(ii)** Determine the moment due to the weight of the steelyard.

moment = ............................................ [1]

**(iii)** Calculate the maximum weight that this steelyard can measure.

weight = ............................................ [2]

**(iv)** On Fig 12.2, mark a scale on the rod so that the weight of an object can be directly read from the position of the 2.0 N weight when the steelyard is balanced. The precision of the scale should be 1 N.

[1]


**Fig. 12.2**

**(b)** Fig. 12.3 shows an empty tumbler placed on a tabletop and is slightly tilted on the right. The tumbler has a uniform mass.

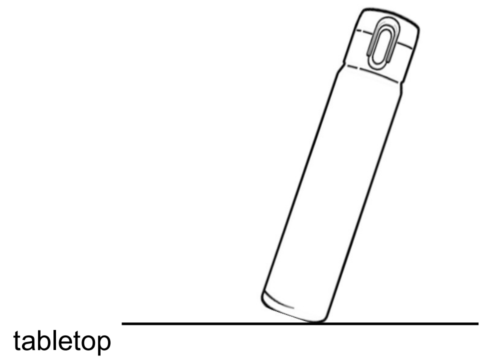



**Fig. 12.3**

**(i)** Explain what is meant by centre of gravity.

..........................................................................................................

.......................................................................................................... [1]

**(ii)** On Fig. 12.3, mark and label the weight of the tumbler and the normal force acting by the table-top on the tumbler. [1]

**(iii)** Explain why the tumbler, shown in Fig. 12.3, will topple.

..........................................................................................................

.......................................................................................................... [1]

**(iv)** The tumbler is now fully filled with water.

State and explain whether the tumbler, fully filled with water, has better stability.

..........................................................................................................

.......................................................................................................... [1]

[Total: 10]

**End of Paper**