

HU Collection
Engineering and Science Admissions Test
Mock Set C
Physics

Time allowed: 40 minutes
Questions: 27 multiple choice
Calculators: not permitted
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Date written: 28 October 2026

Name: Date sat: Score: / 27

Instructions

Answer all 27 questions. Each question has exactly one correct option and is worth one mark. No marks are deducted for wrong answers, so answer every question. Calculators are not permitted. Take the gravitational field strength g to be 10 N kg^{-1} unless a question says otherwise. This paper is deliberately longer than the time allows: move on from any question that is costing you more than two minutes, and come back to it at the end.

Q	1	2	3	4	5	6	7	8	9	10
Ans										

Q	11	12	13	14	15	16	17	18	19	20
Ans										

Q	21	22	23	24	25	26	27			
Ans										

1. A technician rubs a polythene rod with a dry woollen cloth, and the rod becomes negatively charged. No fibres or other material pass between the rod and the cloth. She then holds the rod close to, but not touching, an uncharged metal sphere on an insulating stand. With the rod still in place, she briefly touches the far side of the sphere with a wire connected to earth. She removes the wire, and only then takes the rod away.

Which of the following statements must be true?

- I. During the rubbing, the mass of the cloth decreased.
- II. While the earth wire touched the sphere, protons flowed from the earth onto the sphere.
- III. After the rod has been taken away, the sphere is positively charged.

- A I only
- B II and III only
- C I and III only
- D III only
- E none of them
- F II only
- G I and II only
- H I, II and III

2. A rooftop solar water heater has a flat collector panel and a separate storage tank, joined by two pipes so that water can circulate between them without a pump. Inside the panel the water flows through copper pipes painted matt black, which lie beneath a sheet of glass.

Which of the following statements is/are correct?

- I. For the water to circulate without a pump, the storage tank must be mounted higher than the panel.
- II. Painting the pipes matt black increases the rate at which they absorb infrared radiation from the Sun, and it also increases the rate at which they emit infrared radiation at any given temperature.
- III. The pipe that carries water from the tank to the panel should be connected near the top of the tank.

- A III only
- B I and II only
- C none of them
- D II and III only
- E I, II and III
- F II only
- G I and III only
- H I only

3. A gymnast is 1.80 m tall and her eyes are 1.68 m above the floor. She stands upright on a level floor, 2.0 m from a vertical plane mirror that is fixed flat against a wall, and faces it. The mirror is 0.80 m tall and its lower edge is 0.70 m above the floor. Treat her eyes as a single point vertically above her feet.

Consider the following statements.

- I. The highest point of her body that she can see in the mirror is 1.32 m above the floor.
- II. If she walks backwards, away from the mirror, she will be able to see a greater length of her body in it.
- III. If the mirror were moved 0.24 m higher up the wall, she would be able to see the whole of her body in it.

Which of these statements is/are correct?

- A** I only
- B** I, II and III
- C** III only
- D** II and III only
- E** I and III only
- F** I and II only
- G** none of them

4. A geologist wants to find the density of the mineral grains that make up a porous sandstone: the density of the solid rock material itself, not counting the empty pores.

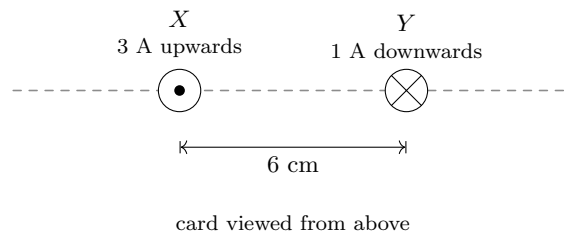
The dry sample has mass 270 g. She soaks it in water until every pore is completely filled, then wipes its outer surface dry; its mass is now 300 g.

Next, a container is filled to the brim with water; the container and water together have mass 1000 g. The soaked sample is lowered gently into the container, so that some water overflows. No further water can enter the sample's pores. The outside of the container is dried, and the container with everything in it now has mass 1180 g.

The density of water is 1.0 g cm^{-3} . What is the density of the mineral grains?

- | | | |
|-----------------------------------|----------------------------------|----------------------------------|
| A 3.3 g cm^{-3} | B 3.0 g cm^{-3} | C 2.5 g cm^{-3} |
| D 2.25 g cm^{-3} | E 1.8 g cm^{-3} | F 1.5 g cm^{-3} |

5. Two long, straight, vertical wires X and Y pass at right angles through a horizontal sheet of card, 6 cm apart. X carries a current of 3 A upwards and Y carries a current of 1 A downwards. The figure shows the card from above. Ignore the Earth's magnetic field.



Which of the following statements must be true?

- I. At the point midway between X and Y, the magnetic fields due to the two wires point in the same direction.
- II. On the straight line through X and Y, on the far side of Y from X, there is a point at which the resultant magnetic field is zero.
- III. The magnetic force on Y is smaller than the magnetic force on X, because Y carries the smaller current.

- A III only
- B II and III only
- C none of them
- D I only
- E I, II and III
- F I and II only
- G II only
- H I and III only

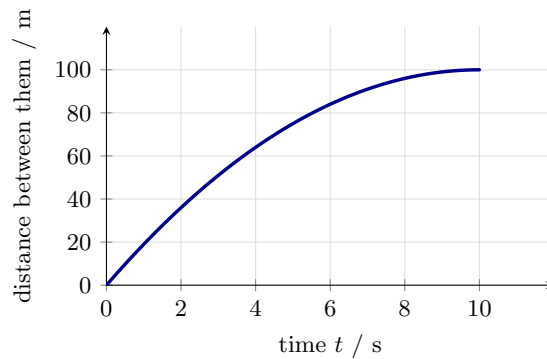
6. A heavy radioactive nuclide P has 80 protons, and the ratio of the number of neutrons to the number of protons in its nucleus is 1.6. It decays through a chain of emissions, each of which is either an alpha particle or a beta-minus particle (gamma rays may also be given off along the way), and the chain ends at a nuclide Q.

Q is an isotope of P, and its ratio of neutrons to protons is 1.4.

How many beta-minus particles are emitted in the whole chain?

- | | | |
|------|-----|------|
| A 8 | B 4 | C 12 |
| D 16 | E 6 | F 2 |

7. An autonomous delivery van is waiting at a junction on a straight road. At time $t = 0$ a lorry travelling at constant speed passes it, and at that instant the van sets off after the lorry with a constant acceleration. A rear-facing sensor on the lorry records the distance between the two vehicles. The graph shows its readings for the first 10 s; the greatest distance, 100 m, occurs at $t = 10$ s.



At what speed is the van travelling when it draws level with the lorry?

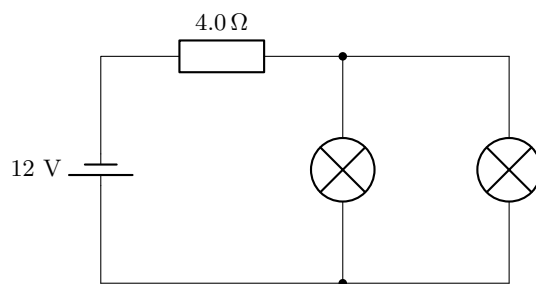
- | | | |
|--|--------------------------------|--|
| A 10 m s^{-1} | B 40 m s^{-1} | C $10\sqrt{2} \text{ m s}^{-1}$ |
| D $20\sqrt{2} \text{ m s}^{-1}$ | E 60 m s^{-1} | F 20 m s^{-1} |

8. Hailstones can be modelled as solid spheres of ice, all with the same density. When a hailstone of radius r falls at speed v , the air resistance on it is kr^2v^2 , where k is the same constant for every hailstone. A hailstone of diameter 1 cm has a terminal speed of 10 m s^{-1} .

A hailstone of diameter 4 cm is falling vertically. At the instant its speed is 10 m s^{-1} , what is the size of its acceleration? Take $g = 10 \text{ m s}^{-2}$.

- | | | |
|---------------------------------|-----------------------------------|---------------------------------|
| A 2.5 m s^{-2} | B 5.0 m s^{-2} | C 0 |
| D 10 m s^{-2} | E 9.375 m s^{-2} | F 7.5 m s^{-2} |

9. Two identical filament lamps are connected in parallel with each other, and this pair is connected in series with a $4.0\ \Omega$ resistor to a $12\ \text{V}$ battery of negligible internal resistance, as shown.



Earlier, a student measured the current I in one of these lamps for several values of the potential difference V across it:

$V\ (\text{V})$	1.0	2.0	4.0	6.0	8.0	10.0
$I\ (\text{A})$	0.45	0.70	1.00	1.20	1.35	1.45

What is the power dissipated in the $4.0\ \Omega$ resistor?

A $4.0\ \text{W}$

B $36\ \text{W}$

C $16\ \text{W}$

D $8.0\ \text{W}$

E $12\ \text{W}$

F $24\ \text{W}$

10. On a dry test track a driver sees a hazard and brakes to a stop. Her stopping distance is the distance travelled at constant speed during her reaction time plus the braking distance, which is travelled with a constant deceleration. From $10\ \text{m s}^{-1}$ her stopping distance is $16\ \text{m}$, and from $20\ \text{m s}^{-1}$ it is $52\ \text{m}$.

On a wet track her reaction time is unchanged, but the braking deceleration is halved. What is her stopping distance on the wet track from $30\ \text{m s}^{-1}$?

A $234\ \text{m}$

B $180\ \text{m}$

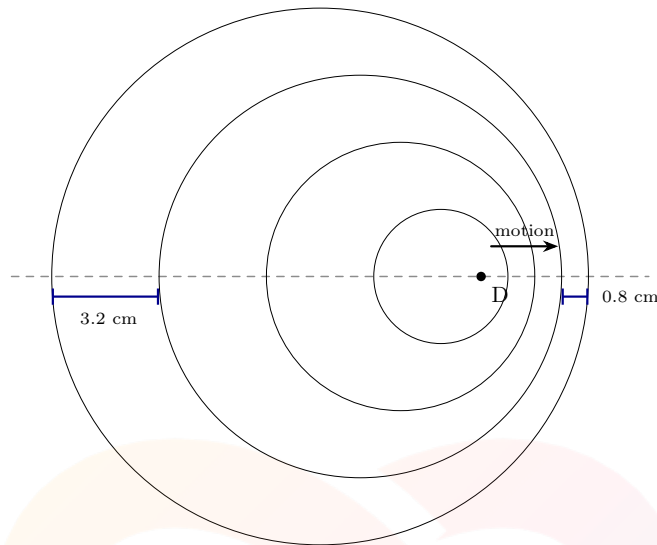
C $198\ \text{m}$

D $288\ \text{m}$

E $216\ \text{m}$

F $108\ \text{m}$

11. In a ripple tank, a small dipper moves in a straight line across the water at a constant speed that is less than the speed of the waves. It dips into the water 5.0 times per second, and each dip starts a circular crest, which spreads out at the wave speed from the point where the dipper was at that moment. The figure, drawn to scale, shows four crests at one instant, with the dipper at D.

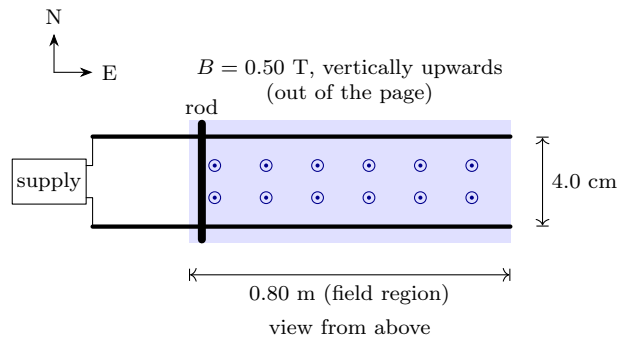


Directly ahead of the dipper the crests are 0.8 cm apart, and directly behind it they are 3.2 cm apart.

What is the speed of the dipper, and at what frequency do crests pass a small cork floating at rest at a point directly ahead of it?

- | | | |
|--|---|---|
| A 6 cm s^{-1} and 3.1 Hz | B 6 cm s^{-1} and 20 Hz | C 12 cm s^{-1} and 12.5 Hz |
| D 6 cm s^{-1} and 12.5 Hz | E 10 cm s^{-1} and 12.5 Hz | F 6 cm s^{-1} and 5.0 Hz |

12. Two straight horizontal metal rails run from west to east, 4.0 cm apart. A metal rod of mass 10 g lies across them, at right angles to them, and can slide along them without friction. Over the last 0.80 m of the rails, up to their east end, there is a uniform magnetic field of flux density 0.50 T directed vertically upwards; there is no field anywhere else. A supply connected to the west ends of the rails drives a constant current through the rod while it is on the rails.



The rod starts from rest at the west edge of the field and is pushed east by the magnetic force. It leaves the east end of the rails and slides onto a smooth insulating ramp, up which it rises to a greatest height of 1.6 m above the rails. Ignore air resistance and take $g = 10 \text{ N kg}^{-1}$.

What is the current in the rod, and in which direction does it flow through the rod?

- A** 10 A, from south to north **B** 20 A, from south to north **C** 20 A, from north to south
D 5.0 A, from south to north **E** 5.0 A, from north to south **F** 10 A, from north to south

13. A pile driver on a building site drops a steel hammer of mass 400 kg from rest through a height of 5.0 m onto the top of a vertical concrete pile of mass 100 kg. The hammer does not bounce: the hammer and pile move downwards together, and the pile is driven a further 10 cm into the ground before stopping. Treat the resistive force from the ground as constant, ignore air resistance and take $g = 10 \text{ N kg}^{-1}$.

What is the resistive force exerted by the ground on the pile?

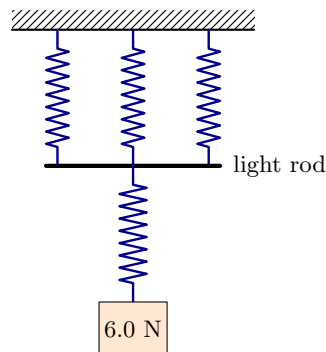
- A** 128 kN **B** 160 kN **C** 200 kN
D 205 kN **E** 165 kN **F** 133 kN

14. A manufacturer makes fuse wire from one alloy in a range of diameters. Use the following model. The resistance of a piece of the wire is proportional to its length and inversely proportional to its cross-sectional area. A piece of the wire melts when the electrical power dissipated in it exceeds a maximum rate of heat loss, and this maximum rate is proportional to the area of its curved surface.

A piece of the wire of diameter 0.20 mm and length 3.0 cm melts when the current in it exceeds 4.0 A. A piece of the same alloy, of length 6.0 cm, is to melt when the current exceeds 32 A. What should its diameter be?

- A** 1.6 mm **B** 12.8 mm **C** 0.40 mm
D 0.57 mm **E** 0.80 mm **F** 1.0 mm

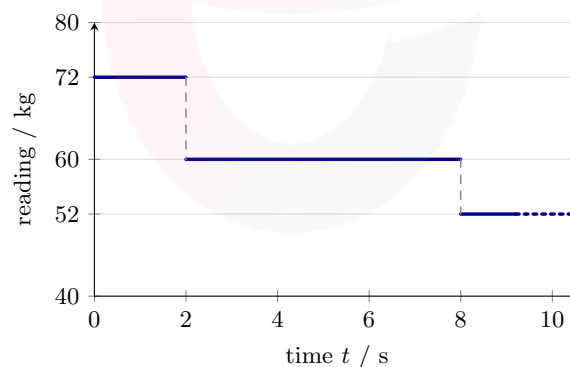
15. A light spring obeys Hooke's law. When a 6.0 N weight hangs at rest from it, it extends by 12 cm. The spring is cut into four pieces of equal length. Three of the pieces hang side by side from a ceiling, equally spaced, and their lower ends are fixed to a short light rod, which stays horizontal. The fourth piece hangs from the midpoint of the rod.



With all four pieces at their natural lengths, the 6.0 N weight is attached to the lower end of the fourth piece and released from rest. What is the greatest elastic energy stored in the arrangement during the motion that follows? Ignore air resistance.

- | | | |
|-----------------|-----------------|-----------------|
| A 0.48 J | B 0.24 J | C 0.72 J |
| D 1.44 J | E 1.92 J | F 0.12 J |

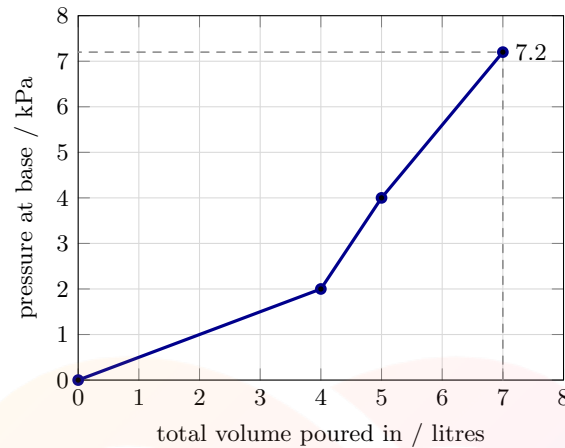
16. A student of mass 60 kg stands on bathroom scales on the floor of a lift. The scales display the upward force they exert on the student divided by 10 N kg^{-1} , in kilograms. The lift starts from rest at time $t = 0$, and the graph shows the reading from $t = 0$ to $t = 8 \text{ s}$.



After $t = 8 \text{ s}$ the reading stays at 52 kg until the lift comes to rest, and then it returns to 60 kg. How far does the lift travel, and in which direction? Take $g = 10 \text{ N kg}^{-1}$.

- | | | |
|-----------------------|-----------------------|-------------------------|
| A 28 m upwards | B 34 m upwards | C 34 m downwards |
| D 36 m upwards | E 32 m upwards | F 30 m upwards |

17. A container is made of two vertical-sided sections: a wide lower section that opens at its top into a narrower upper section directly above it. The upper section is tall enough that no liquid overflows. Water is poured in steadily, and once 5.0 litres of water have been added, oil is poured in on top. The oil does not mix with the water and floats on it. Throughout, a gauge records the pressure at the base of the container due to the liquids alone. The graph shows this pressure against the total volume of liquid poured in.



Take $g = 10 \text{ N kg}^{-1}$ and the density of water as 1000 kg m^{-3} . What are the density of the oil, and the total depth of liquid in the container when 7.0 litres have been poured in?

- A** 800 kg m^{-3} and 0.50 m **B** 3200 kg m^{-3} and 0.80 m **C** 800 kg m^{-3} and 0.72 m
D 1250 kg m^{-3} and 0.80 m **E** 1250 kg m^{-3} and 0.72 m **F** 800 kg m^{-3} and 0.80 m

18. A student measures the count rate from a sample containing a single radioactive isotope, whose decay product is stable, using a detector held in a fixed position. She forgets to measure the background count rate, which stays constant throughout. Her readings, which include background, are:

670 counts per minute at $t = 0$; 190 counts per minute at $t = 6.0$ hours; 70 counts per minute at $t = 12.0$ hours.

Assuming the readings are exact, what will the reading be at $t = 18.0$ hours?

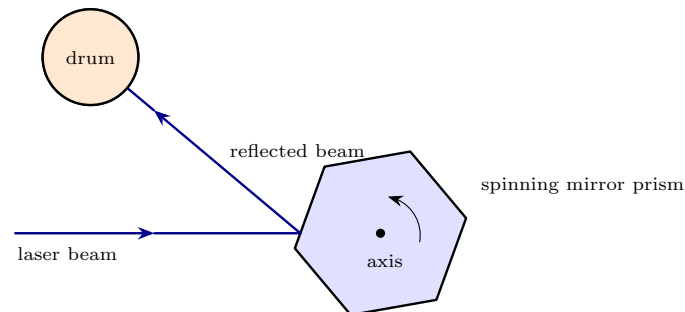
- A** 40 counts per minute **B** 10 counts per minute **C** 17.5 counts per minute
D 30 counts per minute **E** 35 counts per minute **F** 55 counts per minute

19. A space probe is driven by an ion thruster. Xenon atoms are ionised, each losing one electron, so that each ion carries a charge of $+1.6 \times 10^{-19} \text{ C}$. The ions, starting effectively from rest, are accelerated through a potential difference of 1000 V and leave the thruster as a narrow beam. The beam current is 2.0 A. Electrons are also emitted to keep the probe uncharged, but their mass is negligible. Take the mass of a xenon ion to be $2.0 \times 10^{-25} \text{ kg}$.

What is the thrust (the forward force on the probe) produced by the beam?

- A** 0.050 N **B** $4.0 \times 10^3 \text{ N}$ **C** 0.071 N
D $3.2 \times 10^{-3} \text{ N}$ **E** 0.10 N **F** 0.20 N

20. In a laser printer, a fixed laser beam is aimed at a spinning prism whose cross-section is a regular polygon, each side face being a plane mirror. The prism spins about its central axis, which is perpendicular to the beam, at a steady 50 revolutions per second. The beam reflects off one face at a time. While a face is in use, the reflected beam swings steadily round; when the next face takes over, the reflected beam jumps back to the start of its swing. Each such swing of the reflected beam is called a *sweep*. The figure shows a prism with six faces, for illustration only.



The photosensitive drum occupies a fixed 30° range of directions of the reflected beam, which lies within every sweep. The designer needs the reflected beam to be on the drum for exactly one third of the time. How many faces must the prism have, and how many sweeps per second will it then produce?

- A 4 faces and 400 sweeps per second
- B 8 faces and 800 sweeps per second
- C 4 faces and 200 sweeps per second
- D 8 faces and 400 sweeps per second
- E 2 faces and 100 sweeps per second
- F 8 faces and 50 sweeps per second

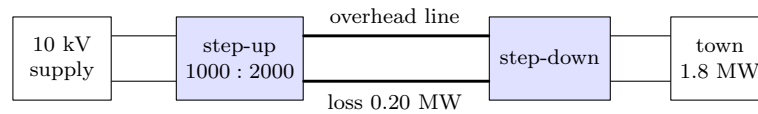
21. In a hospital, a blood warmer heats stored blood before a transfusion. The blood flows steadily through a tube inside an electrically heated block, entering at 7.0°C and leaving at 37.0°C . Some of the electrical power is lost to the surroundings through the casing. To measure the specific heat capacity of blood, a technician runs the warmer at two flow rates, each time adjusting the electrical power until the blood leaves at 37.0°C :

	flow rate of blood	electrical power
Run 1	2.0 g s^{-1}	276 W
Run 2	5.0 g s^{-1}	600 W

In both runs the inlet and outlet temperatures were the same, and the casing settled at the same steady temperature. What value do these results give for the specific heat capacity of blood?

- | | | |
|---|---|---|
| A $4300 \text{ J kg}^{-1} \text{ K}^{-1}$ | B $4400 \text{ J kg}^{-1} \text{ K}^{-1}$ | C $3600 \text{ J kg}^{-1} \text{ K}^{-1}$ |
| D $4600 \text{ J kg}^{-1} \text{ K}^{-1}$ | E $5600 \text{ J kg}^{-1} \text{ K}^{-1}$ | F $4000 \text{ J kg}^{-1} \text{ K}^{-1}$ |

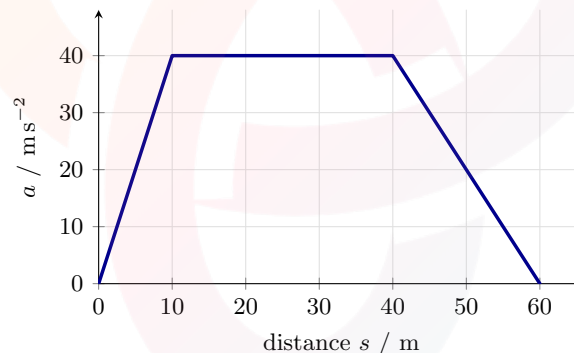
22. A small town draws its electricity along a long overhead line. At the substation, an ideal step-up transformer has a primary coil of 1000 turns supplied at a constant 10 kV, and its secondary coil of 2000 turns feeds the line. At the town end, an ideal step-down transformer takes the power from the line. At present the town receives 1.8 MW and the power dissipated in the line is 0.20 MW.



Engineers will rewind the secondary coil of the step-up transformer so that the power dissipated in the line falls to one quarter of its present value, while the town still receives 1.8 MW. The primary coil and the line are unchanged, and the step-down transformer will be adjusted as needed. How many turns should the new secondary coil have?

- | | | |
|---------------|---------------|---------------|
| A 3600 | B 3700 | C 3800 |
| D 7250 | E 8000 | F 4000 |

23. An electromagnetic launcher accelerates a test sled from rest along a straight, horizontal track. Sensors record the sled's acceleration a against the distance s it has travelled, giving the graph below. The launch ends at $s = 60$ m.



At what distance along the track is the sled moving at exactly half of its final launch speed?

- | | | |
|------------------|------------------|-----------------|
| A 30 m | B 15 m | C 27.5 m |
| D 11.25 m | E 16.25 m | F 5 m |

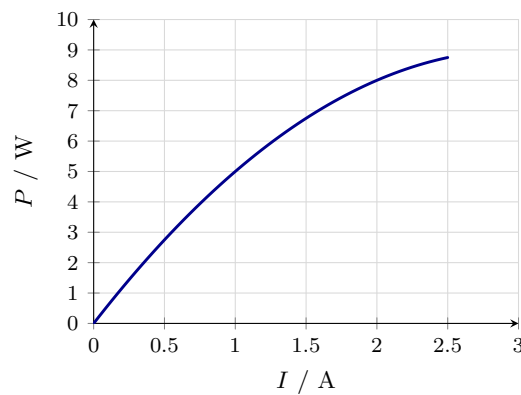
24. A survey ship's echo sounder sends short pulses of ultrasound vertically downwards at regular intervals. In deep water the echo of a pulse may return only after one or more later pulses have been sent, and the instrument cannot tell which pulse an echo belongs to: it simply displays the time between the arrival of an echo and the most recent pulse sent before it.

With pulses sent every 0.30 s, the display reads 0.10 s. With pulses sent every 0.40 s, the display reads 0.20 s. Charts show that the sea bed here lies between 200 m and 1200 m below the ship's transducer. The speed of sound in sea water is 1500 m s^{-1} .

How far below the transducer is the sea bed?

- | | | |
|-----------------|----------------|-----------------|
| A 525 m | B 450 m | C 750 m |
| D 1500 m | E 975 m | F 1050 m |

25. A bench power supply behaves like a source of constant potential difference in series with a fixed internal resistor, both sealed inside its case; neither value is known. A variable resistor is connected across the output terminals. The graph shows how the power P dissipated in the variable resistor depends on the current I in it, for currents up to 2.5 A.



The power is 5.0 W when the current is 1.0 A. There is exactly one other setting of the variable resistor at which the power in it is also 5.0 W. What is the resistance of the variable resistor at that setting?

- | | | |
|------------------------|-----------------------|------------------------|
| A 0.80 Ω | B 1.2 Ω | C 0.31 Ω |
| D 0.20 Ω | E 7.2 Ω | F 1.0 Ω |

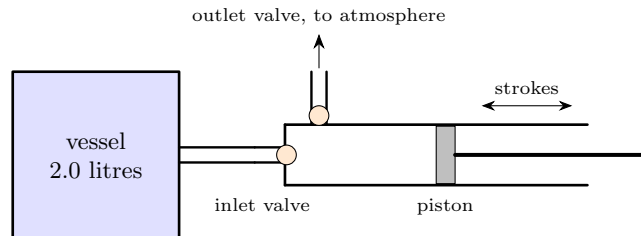
26. An open-topped railway wagon runs along a straight, level track during a cloudburst. Rain falls vertically at a rate equivalent to 90 mm of rainfall per hour, and the open top of the wagon has a horizontal area of 20 m². A locomotive keeps the wagon moving at a constant 4.0 m s⁻¹. Ignore friction and air resistance on the wagon. The density of water is 1000 kg m⁻³.

Which of the following statements is/are correct?

- I. The locomotive must pull the wagon with a horizontal force of 2.0 N.
- II. The locomotive does work on the wagon at twice the rate at which the kinetic energy of the wagon and its contents increases.
- III. If the water instead drained out through holes in the floor as fast as it arrived, falling vertically relative to the wagon, no pulling force would be needed to keep the speed constant.

- A** I, II and III
B II and III only
C I and III only
D I and II only
E III only
F none of them
G I only
H II only

27. A hand vacuum pump is used to remove air from a rigid vessel of volume 2.0 litres, which initially contains air at atmospheric pressure, 100 kPa. The pump is a cylinder with a piston and two one-way valves, as shown. The inlet valve connects the cylinder to the vessel and is open only while the pressure in the cylinder is lower than the pressure in the vessel. The outlet valve connects the cylinder to the atmosphere and is open only while the pressure in the cylinder is higher than atmospheric pressure.



When the piston is fully withdrawn, the volume of gas in the cylinder is 500 cm^3 . Because of the valve fittings, the piston cannot expel all the gas: when it is fully pushed in, a *dead space* of volume 4 cm^3 remains. The pump is worked slowly, always through complete strokes, so that the temperature of the gas stays constant, and no air leaks in.

However many strokes are made, the pressure in the vessel cannot be reduced below a certain value. What is this value?

- A 6.4 Pa
- B 0.40 kPa
- C there is no such value: the pressure can be made as close to zero as we like
- D 0.16 kPa
- E 0.20 kPa
- F 0.80 kPa

End of paper