

HU Collection
Engineering and Science Admissions Test
Mock Set D
Physics

Time allowed: 40 minutes
Questions: 27 multiple choice
Calculators: not permitted
Written by: Kevin Hu
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. Three identical small metal spheres, A, B and C, stand on insulating supports. Whenever two of the spheres are touched together, the total charge on the pair is shared equally between them. Whenever a sphere is connected to earth, it is left with no net charge.

At the start, A carries a charge of $+24 \text{ nC}$, B carries -8 nC and C is uncharged. The following steps are carried out in order, and after each touch the spheres are separated again. Step 1: A touches B. Step 2: B touches C. Step 3: C is connected to earth, then disconnected. Step 4: A touches C. Step 5: C is connected to earth again, then disconnected.

In total, how many electrons pass through the earth connection during the whole sequence, and in which direction? The charge on an electron is $-1.6 \times 10^{-19} \text{ C}$.

- A 5.0×10^{10} electrons, from earth to C
- B 5.0×10^{10} electrons, from C to earth
- C 1.0×10^{11} electrons, from earth to C
- D 2.5×10^{10} electrons, from earth to C
- E 5.0×10^{10} protons, from C to earth
- F 1.0×10^{11} electrons, from C to earth

2. A car of mass 1200 kg slows from 30 m s^{-1} to 20 m s^{-1} on a level road using only its brakes. It then descends a hill at a constant 20 m s^{-1} , again using only its brakes, losing 50 m of height. Throughout, 80% of the mechanical energy lost by the car goes into its four steel brake discs, which have a total mass of 24 kg , and the rest heats other parts. The specific heat capacity of steel is $500 \text{ J kg}^{-1} \text{ K}^{-1}$.

Ignore air resistance and rolling resistance, and assume the discs lose no energy to the surroundings during this time. By how much does the temperature of the discs rise in total? Take $g = 10 \text{ N kg}^{-1}$.

- | | | |
|--------|--------|--------|
| A 76 K | B 60 K | C 20 K |
| D 75 K | E 44 K | F 40 K |

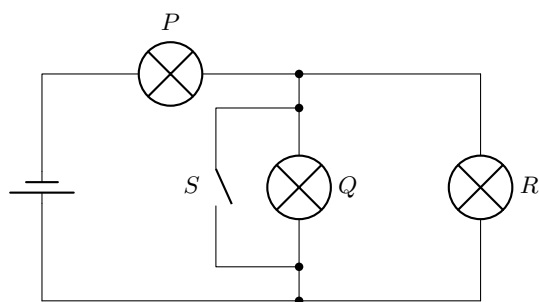
3. In a vacuum, visible light has wavelengths from about 400 nm (violet) to 700 nm (red). A narrow beam of electromagnetic radiation of a single frequency passes from air into a block of glass. In the glass the radiation travels at $2.0 \times 10^8 \text{ m s}^{-1}$ and has wavelength 440 nm . Take the speed of electromagnetic waves in air to be $3.0 \times 10^8 \text{ m s}^{-1}$.

- I. The radiation is visible light from the red end of the spectrum.
- II. The frequency of the radiation in the glass is two thirds of its frequency in the air.
- III. If the beam then passes from the glass into water, in which it travels at $2.25 \times 10^8 \text{ m s}^{-1}$, its wavelength in the water is 495 nm .

Which of these statements is/are correct?

- A I only
- B I and III only
- C II only
- D I, II and III
- E II and III only
- F III only
- G I and II only

4. Three identical lamps P, Q and R are connected to a battery of negligible internal resistance as shown. Treat each lamp as a fixed resistor, and the switch S as having zero resistance when closed. S is open at first.

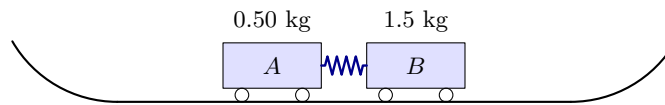


Which of the following statements must be true when S is closed?

- I. Lamp R goes out.
- II. The current from the battery doubles.
- III. The power dissipated in lamp P becomes $\frac{9}{4}$ of its previous value.

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

5. Two trolleys rest on a straight, level, frictionless track that curves smoothly upwards at both ends. Trolley *A* has mass 0.50 kg and trolley *B* has mass 1.5 kg. A light spring of stiffness 1200 N m^{-1} is held compressed by 5.0 cm between them by a thread. The thread is burnt, the spring pushes the trolleys apart and drops away, and each trolley rolls up a curved end of the track.



What is the greatest height above the level track reached by trolley *A*? Take $g = 10 \text{ N kg}^{-1}$.

- | | | |
|-----------------|-----------------|------------------|
| A 2.5 cm | B 30 cm | C 15 cm |
| D 45 cm | E 7.5 cm | F 22.5 cm |

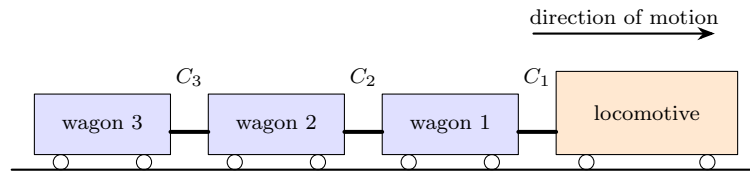
6. Consider the following statements about matter.

- I. When a fixed mass of gas in a sealed syringe is compressed slowly to half its volume at constant temperature, the number of collisions per second that its particles make with each square centimetre of the inside wall doubles.
- II. While water is boiling steadily at 100°C , the energy supplied to it increases the average kinetic energy of its particles.
- III. The particles of 1 kg of steam at 100°C have more energy in total than the particles of 1 kg of liquid water at 100°C .
- IV. While a puddle of water at 20°C evaporates, the average kinetic energy of the particles remaining in the liquid tends to fall unless energy reaches the puddle from its surroundings.

Which of these statements must be true?

- A** III only
B I, III and IV only
C I and IV only
D II and IV only
E III and IV only
F I and III only
G I, II, III and IV

7. A freight train is made up of a locomotive pulling three identical wagons, joined by couplings C_1 , C_2 and C_3 that can push or pull. It is moving along a straight, level track. Ignore air resistance and all friction other than from brakes.



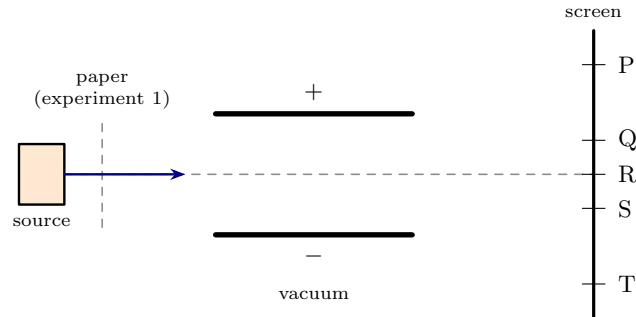
In case 1, only the locomotive's brakes are applied. In case 2, every vehicle has brakes, and the braking force on each vehicle is proportional to its mass. In each case the train slows with a constant deceleration.

Which of the following statements is/are correct?

- I. In case 1, every coupling is being compressed rather than stretched.
- II. In case 1, the force in C_1 is three times the force in C_2 .
- III. In case 2, none of the couplings carries any force.

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

8. A source emits alpha, beta-minus and gamma radiation. In a vacuum, a narrow beam from it passes between two parallel metal plates, the upper one positively charged and the lower one negatively charged, and then strikes a fluorescent screen. Five positions on the screen are marked: P (well above the original line of the beam), Q (slightly above), R (on the line), S (slightly below) and T (well below).

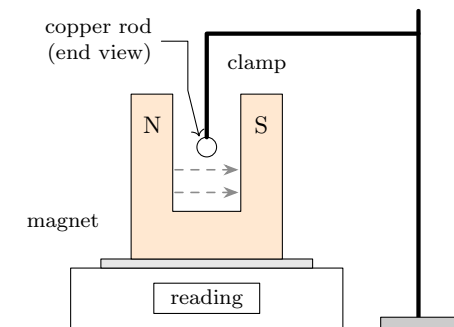


In experiment 1, a sheet of paper is placed over the source. In experiment 2, the paper is removed, and the plates are replaced by a uniform magnetic field directed into the page, filling the same region. Assume that any radiation reaching the screen lands on one of the marked positions.

Which positions glow in each experiment?

- A experiment 1: P and R; experiment 2: Q, R and T
- B experiment 1: T and R; experiment 2: P, R and S
- C experiment 1: R only; experiment 2: Q, R and T
- D experiment 1: P, R and S; experiment 2: Q, R and T
- E experiment 1: S and R; experiment 2: Q, R and T
- F experiment 1: P and R; experiment 2: P, R and S

9. A U-shaped permanent magnet rests on a top-pan balance, with a uniform horizontal magnetic field between its poles. A straight horizontal copper rod is held rigidly in a clamp so that it passes between the poles without touching the magnet. A 5.0 cm length of the rod lies in the field, at right angles to it.



With no current in the rod, the balance reads 312.0 g. With a current of 4.0 A in the rod, it reads 314.4 g. The current is then reversed in direction and increased to 6.0 A. Take $g = 10 \text{ N kg}^{-1}$ and assume there is no field outside the gap.

What is the magnetic flux density between the poles, and what does the balance read now?

- | | | |
|---------------------------|---------------------------|--------------------------|
| A 0.012 T; 308.4 g | B 0.012 T; 315.6 g | C 0.12 T; 308.4 g |
| D 0.12 T; 315.6 g | E 1.2 T; 308.4 g | F 0.12 T; 312.0 g |

10. Three solid objects are made of the same metal and have the same surface finish: a sphere P of radius r , a cube Q of side $2r$, and a sphere R of radius $2r$. They are heated to the same high temperature and then placed in a vacuum chamber with cold walls, where they lose energy only by thermal radiation. For a given surface temperature and finish, the rate at which an object loses energy is proportional to its surface area. Assume that each object's temperature is uniform throughout at every instant.

Which of the following statements is/are correct?

- I. At the start, P and Q are cooling at the same rate, measured in kelvin per second.
- II. At the start, R is cooling at a quarter of the rate of P .
- III. P takes half as long as R to cool from 600°C to 500°C .

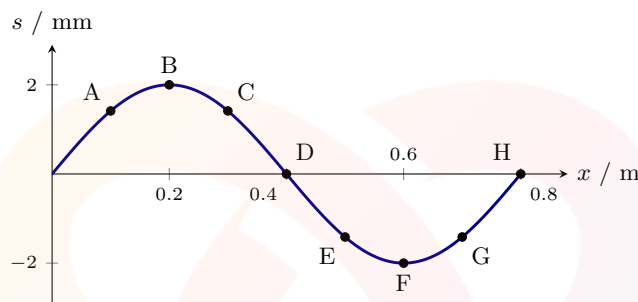
- A** I only
- B** II and III only
- C** I and III only
- D** I and II only
- E** I, II and III
- F** III only
- G** II only
- H** none of them

11. A tram runs between two stops 1.2 km apart on a straight track. It accelerates from rest at 1.0 m s^{-2} up to its maximum permitted speed of 20 m s^{-1} , travels at that speed, and then decelerates at 2.0 m s^{-2} to rest at the next stop. The operator adds an extra stop exactly halfway between the two, where the tram waits for 30 s. The tram uses the same accelerations and the same maximum speed throughout.

By how much does the journey time between the original two stops increase?

- | | | |
|---------------|---------------|----------------|
| A 35 s | B 45 s | C 40 s |
| D 60 s | E 30 s | F 120 s |

12. A longitudinal wave travels to the right along a long stretched spring. The graph shows, at one instant, the displacement s of each coil from its undisturbed position against that undisturbed position x , with displacements to the right counted as positive. Eight coils are labelled A to H.



At this instant, which labelled coil is at the centre of a compression, and which labelled coil is moving to the left with the greatest speed?

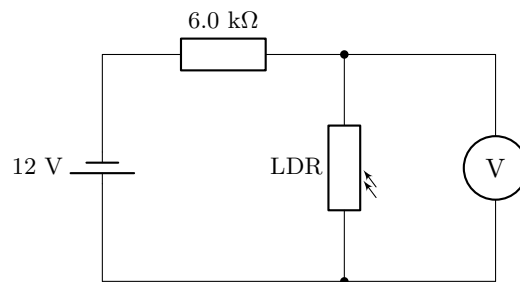
- A** compression at D; fastest leftward coil D
- B** compression at B; fastest leftward coil H
- C** compression at D; fastest leftward coil F
- D** compression at D; fastest leftward coil H
- E** compression at H; fastest leftward coil D
- F** compression at B; fastest leftward coil F

13. A diving bell is a rigid cylinder of uniform cross-section, 3.0 m tall, closed at the top and open at the bottom. Full of air at atmospheric pressure, 100 kPa, it is lowered, upright, into a deep freshwater lake until the water inside it has risen 1.0 m above its open bottom. It is held at this position, and air is then pumped down into it from the surface until it is once again full of air, with the water level inside it at its open bottom.

Take $g = 10 \text{ N kg}^{-1}$ and the density of water as 1000 kg m^{-3} ; the temperature of the air stays constant. Measured at atmospheric pressure, what volume of air must be pumped in, as a fraction of the volume of the bell?

- | | | |
|------------------------|------------------------|-------------------------|
| A $\frac{1}{2}$ | B $\frac{8}{5}$ | C $\frac{8}{15}$ |
| D $\frac{1}{3}$ | E $\frac{3}{5}$ | F $\frac{3}{10}$ |

14. An LDR is connected in series with a fixed $6.0\text{ k}\Omega$ resistor to a 12 V battery of negligible internal resistance, and an ideal voltmeter is connected across the LDR. The LDR is in a room lit only by a dim, steady background light and a small lamp.



Model the situation as follows. The resistance of the LDR is inversely proportional to the total intensity of the light falling on it. The intensities due to the background and to the lamp add together, and the intensity due to the lamp is inversely proportional to the square of its distance from the LDR.

With the lamp switched off, the voltmeter reads 9.0 V . With the lamp switched on, 1.0 m from the LDR, it reads 4.0 V . How far from the LDR should the lamp be placed for the voltmeter to read 7.5 V ?

- | | | |
|--------------------------|-------------------------|--------------------------|
| A 1.8 m | B 1.9 m | C 0.40 m |
| D 6.25 m | E 2.5 m | F 3.3 m |

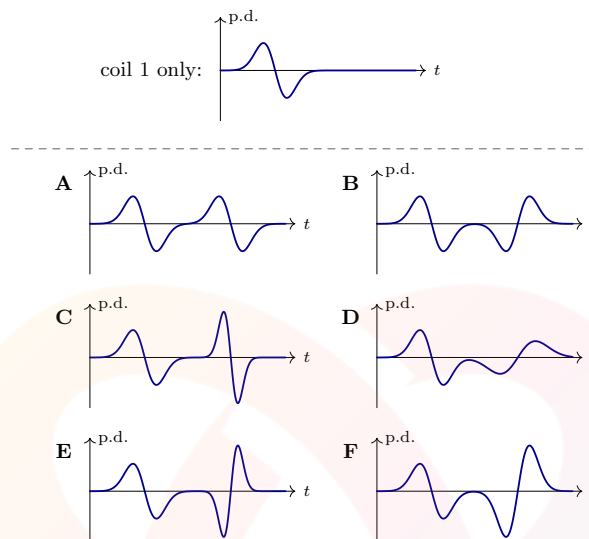
15. A lift car is moving upwards at 5.0 m s^{-1} and slowing down with a constant deceleration of 2.5 m s^{-2} . At this instant a small lamp comes loose from the ceiling of the car, 2.4 m above the floor, and falls. The car keeps the same deceleration while the lamp falls. Ignore air resistance and take $g = 10\text{ m s}^{-2}$.

At what speed, relative to the floor of the car, does the lamp hit the floor?

- | | | |
|--------------------------------------|--------------------------------|---------------------------------------|
| A $4\sqrt{3}\text{ m s}^{-1}$ | B 3.0 m s^{-1} | C $2\sqrt{15}\text{ m s}^{-1}$ |
| D 6.0 m s^{-1} | E 1.0 m s^{-1} | F 11 m s^{-1} |

16. Two identical coils, 1 and 2, are wound on a long vertical plastic tube, with coil 1 well above coil 2. They are connected in series to a voltage sensor and data logger, and coil 2 is wound in the opposite sense to coil 1. A bar magnet is dropped from rest, north pole downwards, from just above coil 1, and falls freely through the tube, passing right through both coils. Air resistance, and any effect of the induced currents on the motion of the magnet, are negligible.

In a first trial, with only coil 1 connected to the logger, the trace at the top of the figure was recorded. The magnet is then dropped in the same way with both coils connected. All the graphs use the same scales.



Which graph could show the new trace?

- | | | |
|------------------|------------------|------------------|
| A Graph A | B Graph B | C Graph C |
| D Graph D | E Graph E | F Graph F |

17. A transformer for a model railway runs from the 230 V mains, and its secondary coil gives an output of 12.0 V. Treat the transformer as ideal. A technician wants an output of 15.0 V, so she winds 40 extra turns of insulated wire onto the core and joins them in series with the secondary coil. By mistake she winds them in the opposite sense to the secondary, and the output falls to 10.0 V. She removes these 40 turns and instead adds the right number of turns, in the correct sense, to give exactly 15.0 V.

How many turns does she add, and how many turns are there on the primary coil?

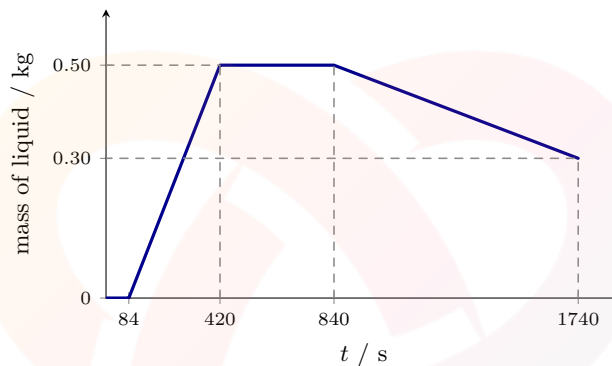
- A** 60 added; 4600 on the primary
- B** 60 added; 2300 on the primary
- C** 30 added; 4600 on the primary
- D** 120 added; 9200 on the primary
- E** 30 added; 2300 on the primary
- F** 20 added; 4600 on the primary

18. A car of mass 1200 kg tows a caravan of mass 600 kg along a straight, level road. The engine delivers a constant useful power of 36 kW. The air resistance on the car is proportional to the square of its speed, and without the caravan the car's top speed is 30 m s^{-1} . At any speed, the air resistance on the caravan is equal to that on the car. Ignore all other resistive forces.

At the instant the car and caravan are moving at 15 m s^{-1} , what is the tension in the tow bar?

- A** 1000 N **B** 700 N **C** 1200 N
D 500 N **E** 600 N **F** 900 N

19. A block of ice of mass 0.50 kg, initially at -40°C , is placed in an insulated vessel containing an electric heater of constant power, which is switched on at time $t = 0$. All the heater's energy goes into the contents, which are kept stirred; the vessel's own heat capacity is negligible, and steam escapes freely. The ice melts at 0°C and the water boils at 100°C . The graph shows the mass of *liquid* water in the vessel against time.



The specific heat capacity of liquid water is $4200 \text{ J kg}^{-1}^\circ\text{C}^{-1}$. According to these results, what are the specific heat capacity of ice and the specific latent heat of vaporisation of water?

- A** $840 \text{ J kg}^{-1}^\circ\text{C}^{-1}$ and 1.5 MJ kg^{-1}
B $336 \text{ J kg}^{-1}^\circ\text{C}^{-1}$ and 2.25 MJ kg^{-1}
C $2100 \text{ J kg}^{-1}^\circ\text{C}^{-1}$ and 2.25 MJ kg^{-1}
D $2100 \text{ J kg}^{-1}^\circ\text{C}^{-1}$ and 1.5 MJ kg^{-1}
E $2100 \text{ J kg}^{-1}^\circ\text{C}^{-1}$ and 0.90 MJ kg^{-1}
F $840 \text{ J kg}^{-1}^\circ\text{C}^{-1}$ and 2.25 MJ kg^{-1}

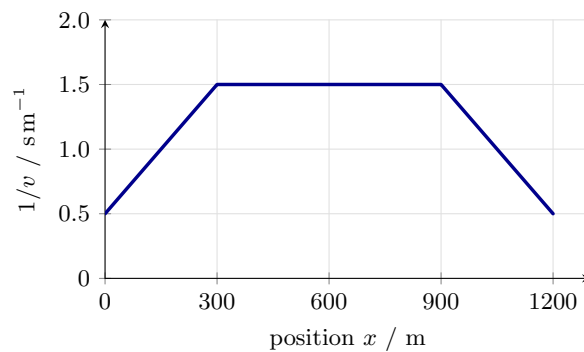
20. A factory makes plastic sheet. To monitor its thickness, a beta source is fixed on one side of the moving sheet and a detector on the other. For this plastic, every extra 0.20 mm of thickness halves the count rate due to the source; the background count rate, 30 counts per minute, is not affected by the sheet. The source has a half-life of 2.6 years.

When the gauge was installed, sheet of thickness 0.60 mm gave a reading of 230 counts per minute. Exactly 5.2 years later, the reading is 55 counts per minute. Both readings include background.

What is the thickness of the sheet now passing through the gauge?

- A** 0.40 mm **B** 0.80 mm **C** 1.00 mm
D 0.60 mm **E** 1.20 mm **F** 1.60 mm

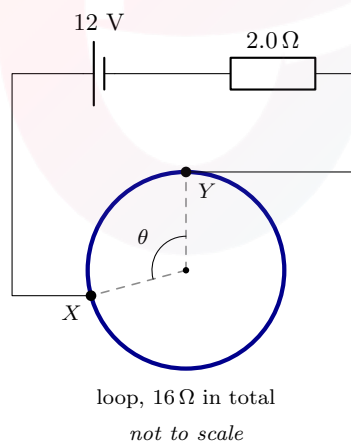
21. A pipeline inspection gauge, a plug-shaped robot pushed along by the flowing oil, travels through a straight 1200 m section of pipeline. Its logger records its speed v at each position x , and the engineers plot $1/v$ against x , as shown.



What is the average speed of the gauge over the whole section?

- A** 0.80 m s^{-1} **B** 1.5 m s^{-1} **C** $\frac{4}{3} \text{ m s}^{-1}$
D $\frac{2}{3} \text{ m s}^{-1}$ **E** 1.25 m s^{-1} **F** 1.0 m s^{-1}

22. A lens demister is a thin circular loop of uniform resistance wire, with a resistance of 16Ω all the way round. The resistance of any piece of the loop is proportional to its length. Two small contacts touch the loop at points X and Y, and are connected in series with a 2.0Ω resistor to a 12 V battery of negligible internal resistance, as shown (the diagram is not to scale). The contacts can be moved around the loop.



The contacts are positioned so that the current from the battery is 2.4 A. What is the angle θ , the smaller of the two angles at the centre between the radii to X and Y?

- A** 67.5° **B** 45° **C** 120°
D 135° **E** about 53° **F** 90°

23. Tank X holds 2.0 kg of water at 80°C and tank Y holds 1.0 kg of water at 10°C . A 2.8 kg steel block, initially at 10°C , is lowered into X and left until it and the water reach the same temperature. It is then moved to Y and left until it and that water reach the same temperature, then back to X , then to Y , and so on, a very large number of times.

The specific heat capacities of water and steel are $4200 \text{ J kg}^{-1} \text{ K}^{-1}$ and $500 \text{ J kg}^{-1} \text{ K}^{-1}$. The water is stirred, the block carries no water between the tanks, and no energy is exchanged with the tanks or the surroundings, including during the moves.

Let Δ_1 be the rise in temperature of the water in Y during the block's first visit to Y , and let Δ be the total rise in temperature of the water in Y by the end of the process. What is Δ_1/Δ ?

- | | | |
|-------------------------|--------------------------|------------------------|
| A $\frac{9}{28}$ | B $\frac{15}{52}$ | C $\frac{3}{8}$ |
| D $\frac{5}{14}$ | E $\frac{5}{12}$ | F $\frac{3}{7}$ |

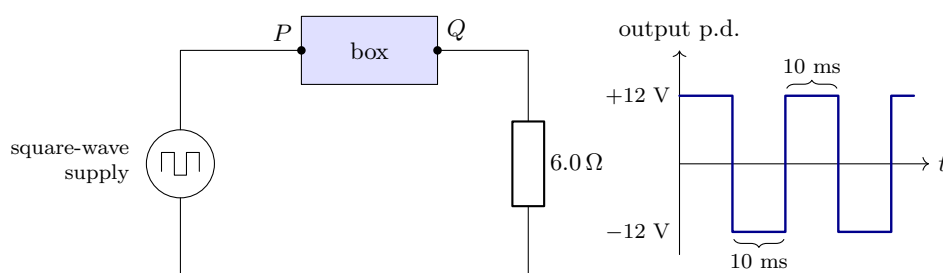
24. A tsunami travels as a shallow-water wave: its speed v depends only on the depth d of the water, according to $v^2 = gd$, where $g = 10 \text{ m s}^{-2}$. A tsunami of period 15 minutes crosses the edge of a continental shelf, where the depth is 250 m. From there to the coast, 50 km away, the depth decreases uniformly with distance, reaching zero at the coastline. Assume that the formula holds all the way to the coast and that the tsunami travels straight towards it.

How long does a crest take to travel from the edge of the shelf to the coast, and what is the wavelength of the tsunami where the depth is 62.5 m?

- | | | |
|-----------------------------|-----------------------------|------------------------------|
| A 1000 s and 45 km | B 2000 s and 45 km | C 2000 s and 11.25 km |
| D 1000 s and 22.5 km | E 2000 s and 22.5 km | F 1000 s and 11.25 km |

25. A sealed box has two terminals, P and Q . It is known to contain only fixed resistors and one ideal diode, which has zero resistance in its forward direction and infinite resistance in reverse. When a 6.0 V d.c. supply is connected across the box with P positive, the current is 2.0 A. With Q positive, the current is 0.50 A.

The box is now connected in series with a 6.0Ω resistor to a supply whose output is a square wave: +12 V for 10 ms, then -12 V for 10 ms, repeating. When the output is +12 V, current enters the box at P . Ignore the time taken to switch between the two values.



What is the mean power dissipated in the 6.0Ω resistor?

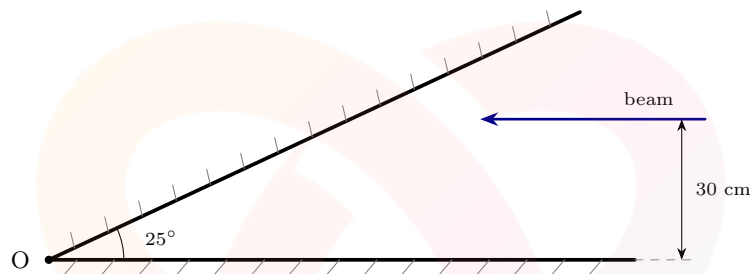
- | | | |
|-----------------------------------|-----------------------------------|-----------------------------------|
| A $\frac{32}{3} \text{ W}$ | B $\frac{16}{3} \text{ W}$ | C $\frac{20}{3} \text{ W}$ |
| D $\frac{2}{3} \text{ W}$ | E 6 W | F $\frac{40}{3} \text{ W}$ |

26. In a simple model of a hovering drone, the rotors take still air and drive it straight downwards as a column whose cross-sectional area A is the area swept out by the rotors, so that the air leaves at speed v . The drone hovers when the rate at which it gives the air downward momentum equals its weight, and the power it needs is the rate at which it gives the air kinetic energy.

At sea level a delivery drone of mass 4.0 kg needs 320 W to hover. In a high-altitude city, where the density of the air is 0.64 times its value at sea level, the same drone hovers while carrying a 5.0 kg parcel. According to the model, what power does it need now?

- | | | |
|-----------------|----------------|-----------------|
| A 1080 W | B 600 W | C 1350 W |
| D 900 W | E 864 W | F 2025 W |

27. Two long plane mirrors are joined along a common edge, which is perpendicular to the page at O, with their reflecting faces inside an angle of 25° . A narrow beam of light enters the gap travelling parallel to the lower mirror, towards the side of the joint, at a perpendicular distance of 30 cm from the lower mirror.



The beam reflects back and forth between the mirrors and eventually leaves through the open side of the gap. How many reflections does it make in total, and what is the least distance between the beam and the joint O at any point of its path?

- | | | |
|-------------------------------|-------------------------------|-------------------------------|
| A 4 reflections; 15 cm | B 8 reflections; 30 cm | C 4 reflections; 30 cm |
| D 7 reflections; 30 cm | E 8 reflections; 15 cm | F 7 reflections; 15 cm |

End of paper