PART B Physics

21 A resistor has a constant voltage of 9.00 V across it.

A total charge of 180 C passes through the resistor in 4.00 minutes.

What is the power dissipated in the resistor?

A 0.750 W

B 6.75 W

C 12.0 W

D 81.0 W

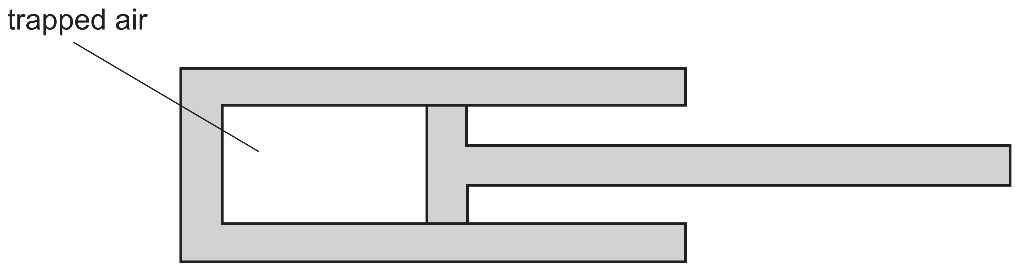
E 108 W

F 405 W

G 1620 W

H 6480 W

22 Air is trapped in a cylinder by a piston. The density of the air in the cylinder is ρ.



The piston is moved so that the pressure of the trapped air increases by 20%. The temperature of the trapped air does not change.

What is the new density of the trapped air?

(Assume that air is an ideal gas.)

A 0.69ρ

B 0.80ρ

C 0.83ρ

D 1.00ρ

E 1.20ρ

F 1.44ρ

23 A **non-ideal** transformer has 100 turns on the primary coil and 25 turns on the secondary coil.

It is provided with 3.0 kW of electrical power at a current of 12.5 A.

The voltage output is the same as for an ideal transformer, but the current in the output coil is 40 A.

What is the efficiency of the transformer?

A 20%

B 25%

C 31%

D 69%

E 75%

F 80%

G 91%

H 100%

24 A car of mass 1400 kg is towing a caravan of mass 1000 kg along a straight horizontal section of road at a constant speed.

The driving force from the engine is increased by 3000 N, causing the car and caravan to accelerate.

At one moment during this acceleration, the resistive force on the car has increased by 200 N and the resistive force on the caravan has increased by 400 N.

What is the acceleration of the car and caravan at this moment?

A $1.00\,m\,s^{-2}$

B $1.25\,m\,s^{-2}$

C $1.50\,m\,s^{-2}$

D $2.00\,m\,s^{-2}$

E $2.60\,m\,s^{-2}$

25 A star is moving away from a space telescope positioned above the Earth. The star emits light of frequency f and wavelength λ at the speed of light c.

This light travels towards the space telescope through the vacuum of space until it is detected on the space telescope.

The frequency, the wavelength and the speed of the light measured at the telescope are f_T, λ_T and c_T respectively.

How do f_T, λ_T and c_T compare with f, λ and c?

	f_T	λ_T	c_T
A	equal to f	equal to λ	equal to c
B	equal to f	equal to λ	less than c
C	equal to f	greater than λ	equal to c
D	equal to f	greater than λ	less than c
E	less than f	equal to λ	equal to c
F	less than f	equal to λ	less than c
G	less than f	greater than λ	equal to c
H	less than f	greater than λ	less than c

26 Q is an element with several isotopes.

The nuclide ${}^{(3x-7)}_{x}\mathrm{Q}$ contains 6 neutrons more than the nuclide ${}^{(2x+3)}_{x}\mathrm{Q}$.

Another isotope of Q is the nuclide ${}^{(3x+1)}_{x}\mathrm{Q}$.

How many neutrons does the nuclide ${}^{(3x+1)}_{x}\mathrm{Q}$ contain?

A 9

B 16

C 19

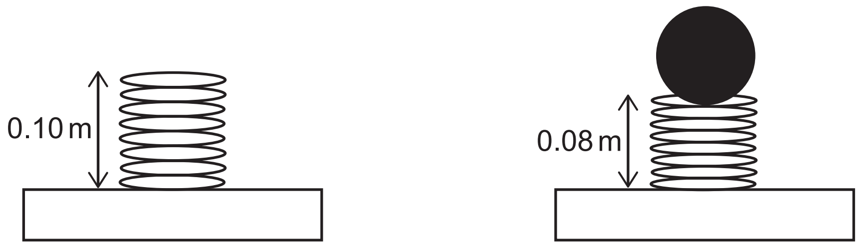
D 21

E 25

F 33

G 49

27 A light spring has an uncompressed length of 0.10 m. When an object of mass 0.5 kg rests in equilibrium on top of the spring, the length of the spring reduces to 0.08 m as shown.



What is the energy stored in the spring due to the compression?

(gravitational field strength = 10 N kg^{-1}; the spring obeys Hooke's law)

A 0.005 J

B 0.02 J

C 0.05 J

D 0.1 J

E 0.2 J

F 0.4 J

28 A set of decorative lights consists of 20 lamps connected in series to a dc supply of constant voltage.

The total power transferred by all the lamps is P.

The set is designed so that if one of the lamps fails, that lamp becomes short-circuited and it then has zero resistance. The remaining lamps are still lit.

If this happens, with the set connected to the same supply, what is the new total power transferred by the remaining 19 lamps?

(Assume that the resistance of each functioning lamp remains constant.)

A $\left(\frac{19}{20}\right)^2 P$

B $\left(\frac{19}{20}\right) P$

C P

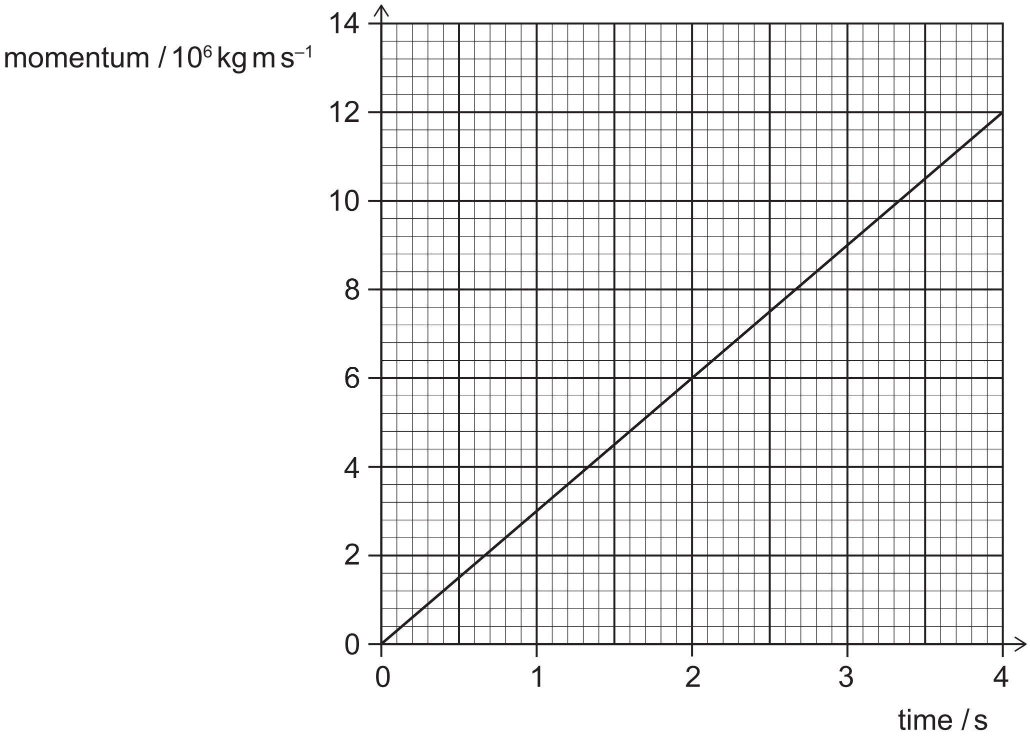
D $\left(\frac{20}{19}\right) P$

E $\left(\frac{20}{19}\right)^2 P$

29 A train accelerates from rest along a straight, horizontal section of track.

The force exerted on the train due to its motors is constant and there is a constant friction force of 1.8×10^{7} N.

The graph shows how the momentum of the train changes with time.



What is the force exerted on the train due to its motors?

A 3.0×10^{6} N

B 6.0×10^{6} N

C 1.2×10^{7} N

D 1.5×10^{7} N

E 2.1×10^{7} N

F 2.4×10^{7} N

G 3.0×10^{7} N

H 4.2×10^{7} N

30 A ship travels into a wave that is travelling in the opposite direction to the ship.

The ship has a horizontal speed of $8.0\,\mathrm{m\,s^{-1}}$. The speed of the wave is $3.0\,\mathrm{m\,s^{-1}}$.

The front of the ship rises and falls with a time period of 8.0 s.

What is the wavelength of the wave?

A $\frac{3}{8}$ m

B $\frac{5}{8}$ m

C 1.0 m

D $\frac{11}{8}$ m

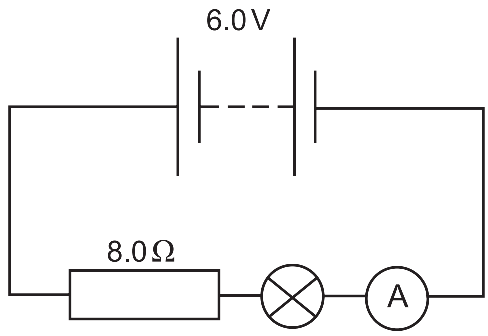
E 24 m

F 40 m

G 64 m

H 88 m

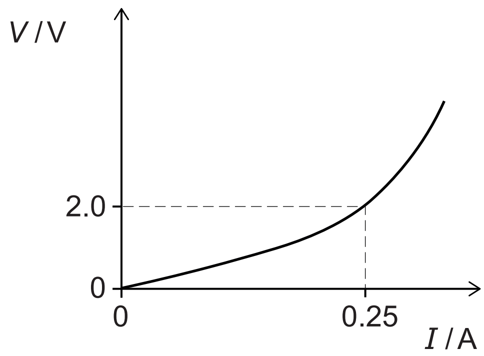
31 A 6.0 V battery is connected to an 8.0 Ω resistor and a filament lamp as shown in the circuit diagram.



The reading on the ammeter is 0.25 A.

Which graph is a possible *V*–*I* graph for the filament lamp?

A



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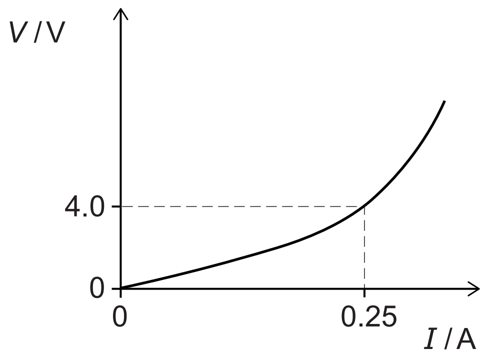

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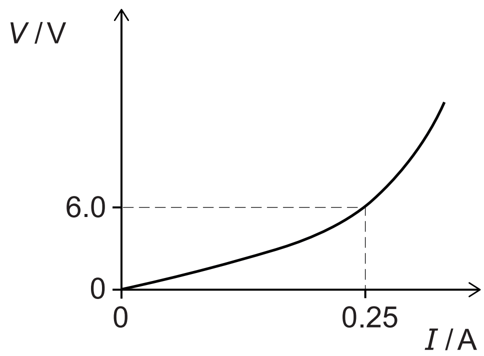

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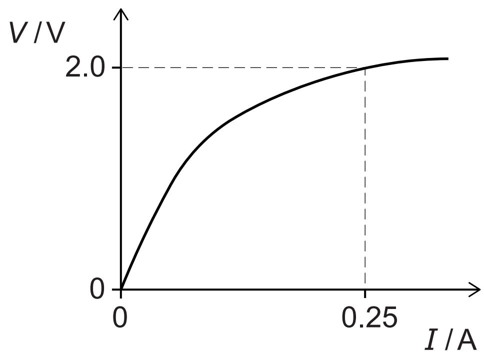

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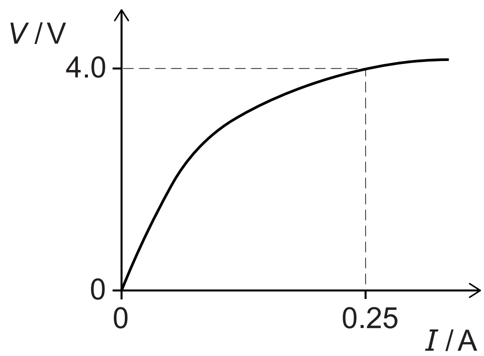

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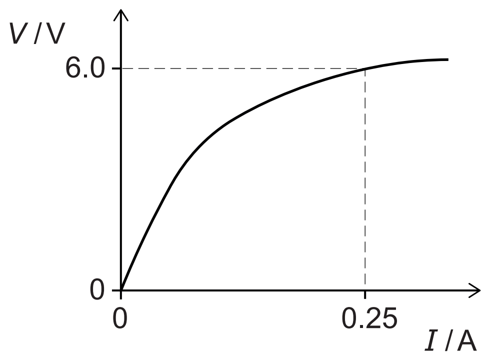


32 A uniform, horizontal magnetic field has magnetic field strength 0.60 T and a direction from west to east.

A horizontal wire is placed in a north–south direction, so that it is at 90° to the magnetic field.

The wire carries a constant current.

The wire has length 0.40 m and mass 0.018 kg.

The resultant force acting vertically on the wire is zero.

What are the magnitude and direction of the current in the wire?

(gravitational field strength = $10\,\mathrm{N\,kg^{-1}}$)

	magnitude of current / A	*direction of current*
A	0.012	from north to south
B	0.012	from south to north
C	0.075	from north to south
D	0.075	from south to north
E	0.12	from north to south
F	0.12	from south to north
G	0.75	from north to south
H	0.75	from south to north

33 The wavelength range of visible light is 400-700 nm.

Light with a frequency of 6.0×10^{14} Hz is green.

Microwaves used in cooking have a wavelength of 12 cm.

Which of the following statements is/are correct?

1 Light with a frequency of 7.5×10^{14} Hz is red.

2 Microwaves used in cooking have a frequency of 2.5×10^{9} Hz.

3 Electromagnetic radiation with a frequency of 2.5×10^{15} Hz can be used in thermal imaging of a building.

(speed of light $= 3.0 \times 10^{8}\,\mathrm{m\,s^{-1}}$)

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

34 There is a high-speed straight railway line between two cities that are 60 km apart. The train stops at both cities.

The train accelerates at a uniform rate of $1.5\,\mathrm{m\,s^{-2}}$ to a maximum speed of $120\,\mathrm{m\,s^{-1}}$.

When braking, it decelerates at a uniform rate of $2.0\,\mathrm{m\,s^{-2}}$.

What is the minimum time taken by the train to travel from one city to the other?

A 140 s

B 355 s

C 430 s

D 500 s

E 570 s

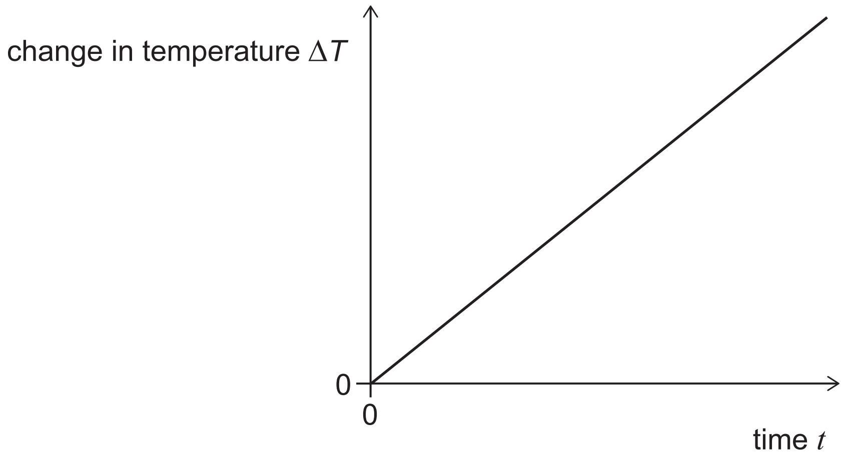
F 860 s

G 1000 s

35 A metal block has mass M.

Heat is transferred to the block at a constant rate P.

The graph shows how the change in temperature ΔT of the block from its initial temperature varies with time t.



The gradient of the line is k.

Which expression gives the specific heat capacity of the metal from which the block is made?

(Assume that no heat is transferred out of the block during the time interval shown by the graph.)

A $\frac{1}{MPk}$

B $\frac{M}{Pk}$

C $\frac{Mk}{P}$

D $\frac{P}{Mk}$

E $\frac{PM}{k}$

F $\frac{Pk}{M}$

G $\frac{k}{MP}$

H MPk

36 A skydiver of mass 80 kg is accelerating vertically downwards through the air. At one instant in time the skydiver has a speed of $5.0\,\mathrm{m\,s^{-1}}$. After travelling a further distance of 20 m downwards the skydiver's speed has increased to $10\,\mathrm{m\,s^{-1}}$.

What is the average force of air resistance acting on the skydiver over the 20 m?

(gravitational field strength = $10\,\mathrm{N\,kg^{-1}}$)

A 600 N

B 650 N

C 750 N

D 790 N

E 950 N

37 A radioactive nuclide X decays in a single stage to a stable nuclide R.

A radioactive nuclide Y decays in a single stage to a stable nuclide S.

When a rock formed it contained equal numbers of atoms of all four nuclides X, Y, R and S.

The half-life of X is T years and the half-life of Y is $2T$ years.

What is the value of $\dfrac{\text{number of atoms of R}}{\text{number of atoms of S}}$ at a time $4T$ years after the rock has formed?

(Assume that no other processes add or remove X, Y, R or S from the rock during this time.)

A $\dfrac{1}{4}$

B $\dfrac{17}{20}$

C $\dfrac{31}{28}$

D $\dfrac{6}{5}$

E $\dfrac{5}{4}$

F 2

38 A beaker containing 180 g of water at 25 °C has a 20 g ice cube at 0 °C added to it.

No heat is transferred between the water and the surroundings (including the beaker).

What is the final temperature of all the water in the beaker after all the ice has melted?

(Take the specific heat capacity of water to be $4\,J\,g^{-1}\,°C^{-1}$ and the specific latent heat of fusion of water to be $300\,J\,g^{-1}$.)

A 2.5 °C

B 8.3 °C

C 10.0 °C

D 15.0 °C

E 16.7 °C

F 22.5 °C

39 Liquid X has density $0.80\,g\,cm^{-3}$ and liquid Y has density $1.0\,g\,cm^{-3}$.

$80\,cm^3$ of liquid X and $100\,cm^3$ of liquid Y are poured into a cylindrical container and allowed to settle. The two liquids do not mix or react.

The internal cross-sectional area of the container is $20\,cm^2$. The base of the container rests on a horizontal surface.

What is the pressure due to the liquids at a height of 4.0 cm above the interior of the base of the container?

(gravitational field strength = $10\,N\,kg^{-1}$)

A 10 Pa

B 40 Pa

C 42 Pa

D 50 Pa

E 100 Pa

F 400 Pa

G 420 Pa

H 500 Pa

40 A pulse of ultrasound travels from one end of a solid uniform rod of length L, starting at time $t = 0$.

The pulse is partially reflected by a crack in the rod and partially by the far end of the rod.

These two reflected pulses travel back along the rod, arriving at the end from which they started at times t_1 and t_2, where $t_2 > t_1$.

What is the distance between the crack and the **far end** of the rod?

A $\frac{t_1}{t_2}L$

B $\frac{t_2}{t_1}L$

C $\frac{t_1}{2t_2}L$

D $\frac{t_2}{2t_1}L$

E $\frac{(t_2 - t_1)}{t_2}L$

F $\frac{(t_2 - t_1)}{2t_2}L$

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