RAFFLES INSTITUTION
2015 Preliminary Examination

PHYSICS **9646/01**
Higher 2

29 September 2015
Paper 1 Multiple Choice Questions **1 hours 15 minutes**

Additional Materials: OMR Form

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write in soft pencil.
Write your index number, name and class on the OMR Form. Shade the appropriate boxes.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the OMR Form.

Read the instructions on the OMR Form very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.

This booklet consists of **18** printed pages including the cover page.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-\dfrac{Gm}{r}$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_0 \cos \omega t$
	v	=	$\pm\omega\sqrt{\left(x_0^2 - x^2\right)}$
mean kinetic energy of a molecule of an ideal gas,	E	=	$\frac{3}{2}kT$
resistors in series,	R	=	$R_1 + R_2 + \ \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ \ldots$
electric potential,	V	=	$\dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	x	=	$x_0 \sin \omega t$
transmission coefficient,	T	=	$\exp(-2kd)$
	where k	=	$\sqrt{\dfrac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\dfrac{0.693}{t_{1/2}}$

1 A student attempts to determine the heights of 2 buildings by taking numerous measurements at different parts of the buildings. The extreme values of each set of data are shown below.

	minimum value	maximum value
height of building 1	12.5 m	12.9 m
height of building 2	11.3 m	12.1 m

How should the difference in the heights of the buildings be expressed?

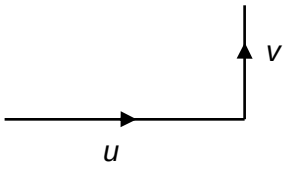
A (0.6 ± 0.2) m

B (0.6 ± 0.6) m

C (1.0 ± 0.2) m

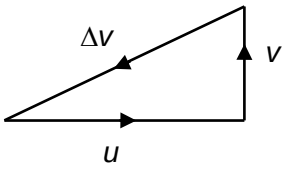
D (1.0 ± 0.6) m

2 A boat changes its velocity from u due east to v due north.



Which diagram correctly indicates the change in velocity Δv of the boat?

A



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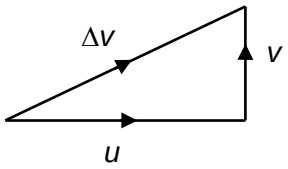
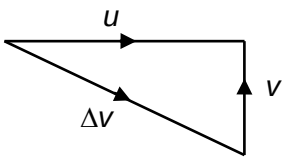


C



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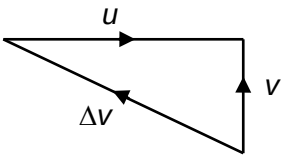
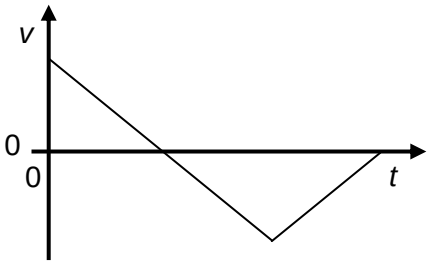


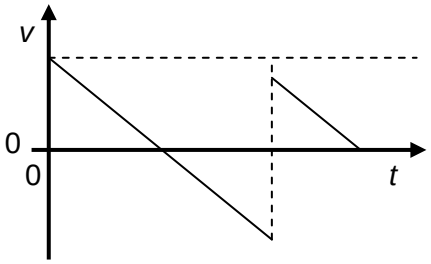
3 A tennis ball is thrown vertically upwards from the ground level. It rises before falling towards the ground and bounces up.

Which of the following graphs represents the variation with time *t* of velocity *v*?

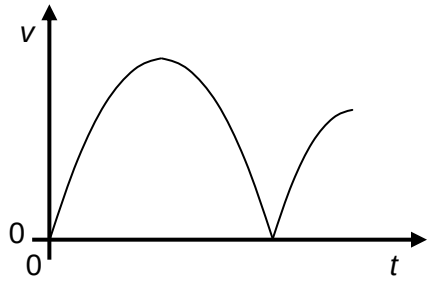
A



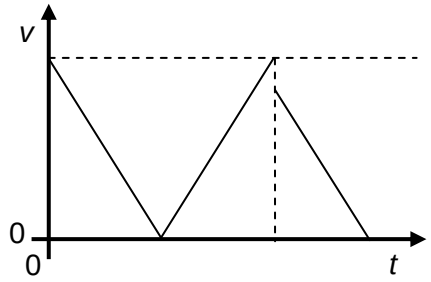
B



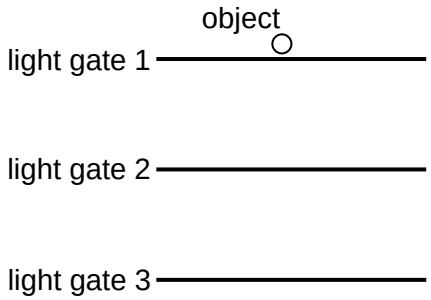
C



D



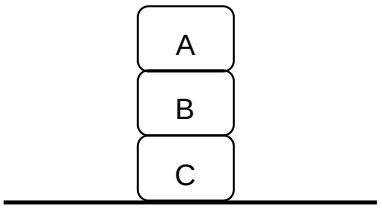
4 An object is released from rest just above light gate 1 as shown. It falls freely through three light gates that are placed at the same distance apart. The object takes time *t* to fall between light gate 1 and light gate 2.



What is the time taken for the object to fall between light gate 2 and light gate 3?

A 0.41 *t* **B** 0.71 *t* **C** *t* **D** 1.4 *t*

5 Three objects A, B and C are stacked on top of one another on the ground.



Which of the following statements is correct?

A The force exerted by object B on object C is equal to the weight of object B.

B The force exerted by object C on object B is greater than the force exerted by object A on object B.

C The weight of object A and the force exerted by object B on object A are an action-reaction pair of forces.

D The normal contact force exerted by the ground on object C is equal to the weight of object C.

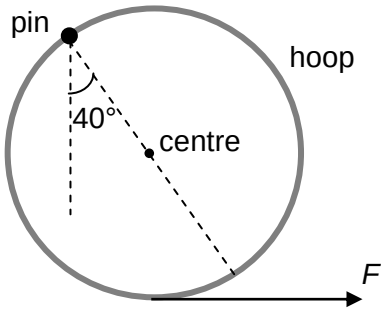
6 A particle of mass m travelling with velocity 150 m s^{-1} collides elastically with a stationary particle of mass $9m$.

What is the speed of the lighter particle after the collision?

A 30.0 m s^{-1} **B** 120 m s^{-1} **C** 135 m s^{-1} **D** 150 m s^{-1}

7 A uniform hoop of weight 20 N can rotate freely about a pin fixed to a wall.

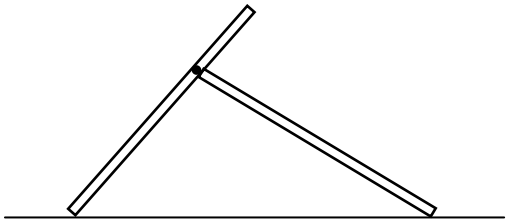
The hoop is held at an angle of 40° by a horizontal force F as shown.



What is the value of F?

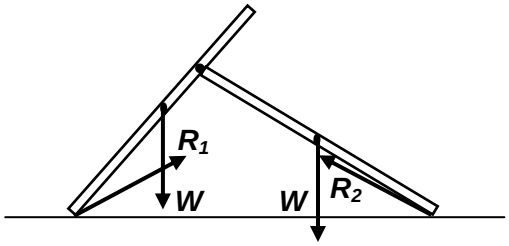
A 7.3 N **B** 7.8 N **C** 9.3 N **D** 17 N

8 Two identical uniform rods, each of weight W, are hinged together to form a structure which is resting on a rough floor as shown.

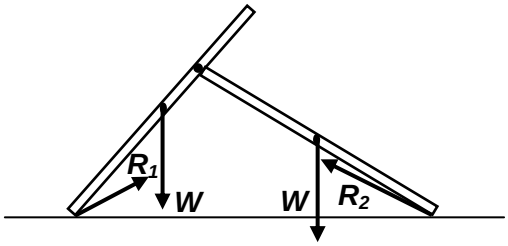


If the reaction forces acting on the structure by the floor are R_1 and R_2, which of the following shows the forces acting on the structure?

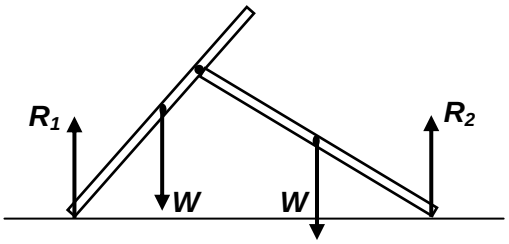
A



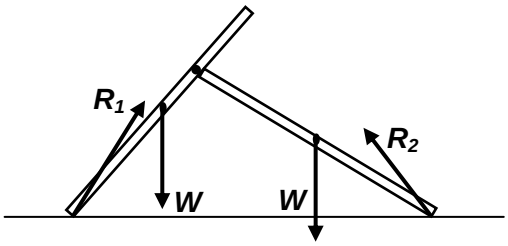
B



C



D



9 A bungee jumper of mass 80.0 kg is attached to a bridge by an elastic rope 30.0 m long. A river flows 46.0 m below the bridge.

If the jumper steps off the bridge and first comes to rest 1.0 m above the river, what is the force constant of the rope?

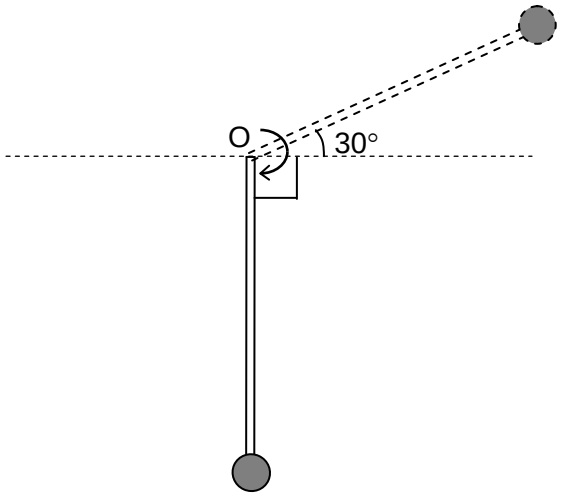
A 52.3 N m^{-1} **B** 209 N m^{-1} **C** 282 N m^{-1} **D** 314 N m^{-1}

10 With its engine turned off, a truck of mass 4.0×10^3 kg rolls down a slope at a constant speed of 6.0 m s^{-1}.

If the slope makes an angle of 5.0° to the horizontal, what power must be delivered by the engine to move the truck up the slope at the same speed?

A 6.8 kW **B** 21 kW **C** 41 kW **D** 470 kW

11 A bob of mass *m* is attached to one end of a light rod which is free to rotate in the vertical plane about point O as shown. The rod is released from rest at an angle of 30° above the horizontal.



What is the tension in the rod when the bob is directly below O?

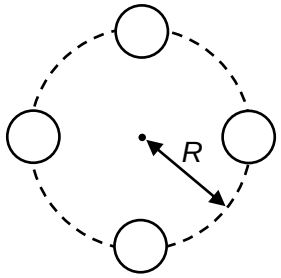
A *mg* **B** 2.0 *mg* **C** 4.0 *mg* **D** 4.7 *mg*

12 Two wooden cubes of masses *m* and $\frac{1}{4}m$ are placed on a turntable. When the turntable rotates at a constant rate, both cubes remain stationary relative to the turntable.

If the cube of mass *m* is at a distance *r* from the centre of the turntable, what is the corresponding distance for the lighter cube? The frictional force acting on each cube is proportional to its mass.

A $\frac{1}{4}r$ **B** r **C** $2r$ **D** $4r$

13 Four bodies of equal mass M are equally spaced in a circle of radius R.



What is the net force on each body?

A $\frac{0.25GM^2}{R^2}$ **B** $\frac{0.96GM^2}{R^2}$ **C** $\frac{1.3GM^2}{R^2}$ **D** $\frac{1.7GM^2}{R^2}$

14 A satellite orbiting the Earth is moved from one stable orbit to another with a smaller radius.

Which of the following statements is true?

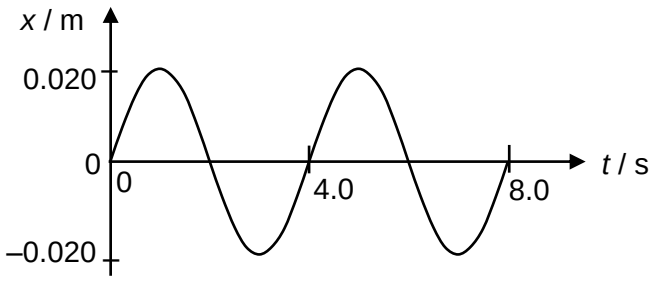
A The linear speed of the satellite increases.

B The angular speed of the satellite remains constant.

C The gravitational force acting on the satellite decreases.

D The gravitational potential energy of the satellite increases.

15 A particle moves with simple harmonic motion about a point P. The graph shows the variation with time t of its displacement x from P.



Which of the following statements is incorrect?

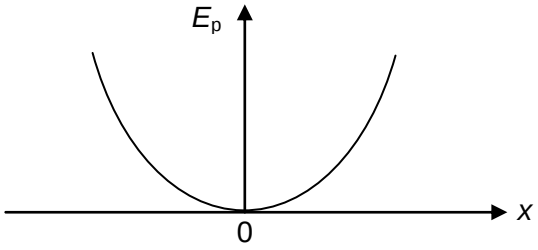
A At distance 0.010 m away from P, the speed is 0.027 m s^{-1}.

B The total distance travelled between 0 s and 1.5 s is 0.030 m.

C The maximum speed of 0.031 m s^{-1} occurs at 2.0 s.

D The maximum acceleration of 0.049 m s^{-2} occurs at 1.0 s.

16 The graph shows the variation of potential energy E_p of a body with its displacement x from a fixed point O.



Which feature of the graph indicates that the net force on the body is directed towards O?

A The graph passes through the origin.

B The graph is symmetrical about the vertical axis.

C The potential energy increases as the body moves away from O.

D The value of the potential energy is positive.

17 Free neutrons may be assumed to behave like particles of an ideal gas in a fission reactor.

What is the root-mean-square speed of one such neutron at a temperature of 35 °C?

A $9.3\times10^{2}\ \text{m s}^{-1}$ **B** $2.8\times10^{3}\ \text{m s}^{-1}$ **C** $8.7\times10^{5}\ \text{m s}^{-1}$ **D** $7.6\times10^{6}\ \text{m s}^{-1}$

18 In which of the following changes does the internal energy of the body increase?

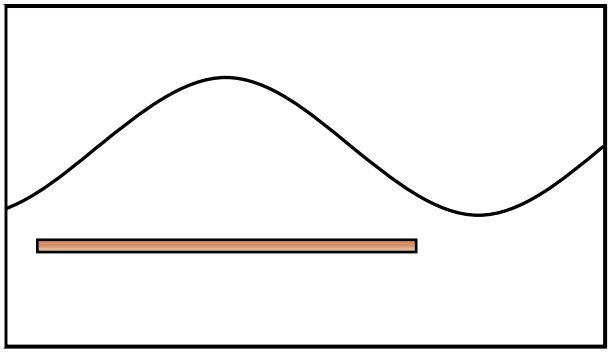
A Mercury freezing at a constant temperature.

B Water vapour condensing at a constant temperature.

C A stone falling freely in a vacuum.

D A wire being stretched at a constant temperature.

19 A photographer uses a digital camera to capture images of a metre rule and a wave on a vibrating rope at 10 frames per second, i.e. 10 photographs are taken in 1 second. However, when he looked at the photographs, all of them looked identical to the figure shown.

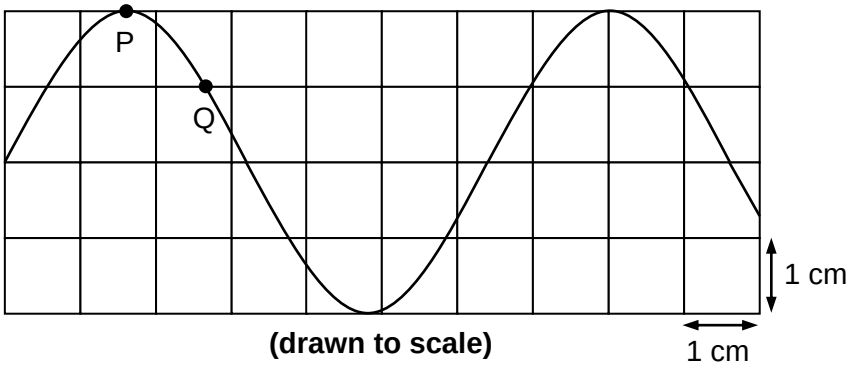


(drawn to scale)

What is the slowest possible speed for the wave?

A 0.80 m s^{-1} **B** 10 m s^{-1} **C** 13 m s^{-1} **D** 20 m s^{-1}

20 The graph shows the variation of displacement with distance of a transverse progressive wave travelling to the left.



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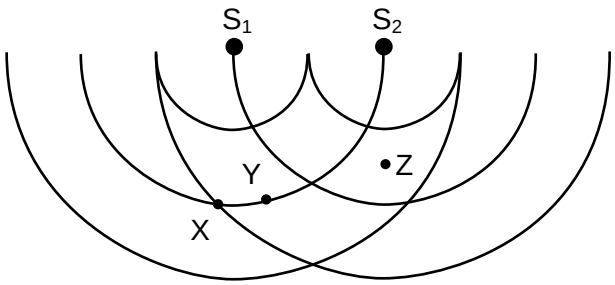
What is the direction of motion of particle Q, and the phase angle between particles P and Q?

	direction of motion of particle Q	phase angle between particles P and Q
A	upwards	30°
B	upwards	60°
C	downwards	30°
D	downwards	60°

21 The figure shows the instantaneous positions of wave crests from two identical point sources S_1 and S_2.



Which of the following correctly describes the type of interference at positions X, Y and Z?

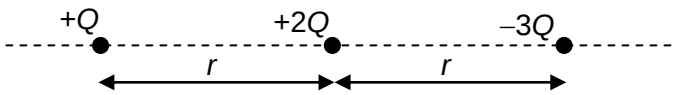
	position X	position Y	position Z
A	constructive	constructive	destructive
B	constructive	destructive	constructive
C	destructive	destructive	constructive
D	destructive	constructive	destructive

22 A wire of length 1.20 m is stretched between two points under a constant tension such that the speed of waves along the wire is 300 m s^{-1}. When the wire is plucked near one end, a standing wave is produced in which the distance between consecutive nodes is 0.40 m.

What are the frequency of the standing wave produced and the fundamental frequency of the system (i.e. the lowest resonant frequency)?

	frequency of standing wave	fundamental frequency
A	375 Hz	125 Hz
B	375 Hz	250 Hz
C	750 Hz	125 Hz
D	750 Hz	250 Hz

23 Three particles of charges $+Q$, $+2Q$ and $-3Q$ are fixed along a straight line at a distance r apart.



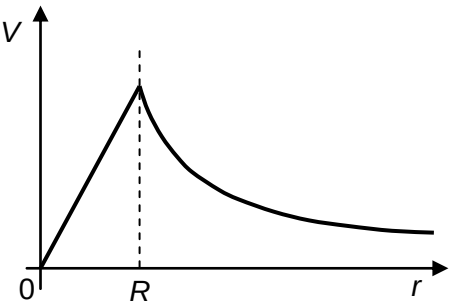
What is the magnitude of the resultant electric force acting on charge $+Q$?

A $\dfrac{Q^2}{8\pi\varepsilon_0 r^2}$ **B** $\dfrac{Q^2}{4\pi\varepsilon_0 r^2}$ **C** $\dfrac{5Q^2}{16\pi\varepsilon_0 r^2}$ **D** $\dfrac{11Q^2}{16\pi\varepsilon_0 r^2}$

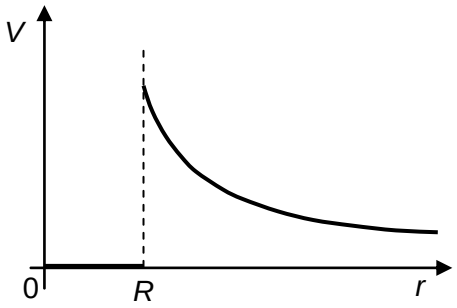
24 A hollow conducting sphere of radius R carries a positive charge.

Which graph shows how the electric potential V varies with distance r from the centre of the sphere?

A



B



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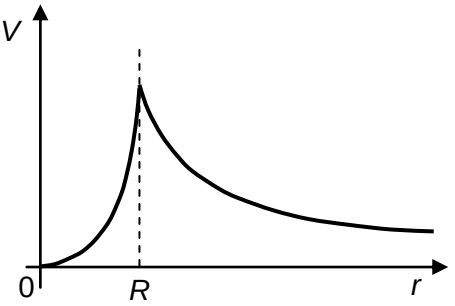
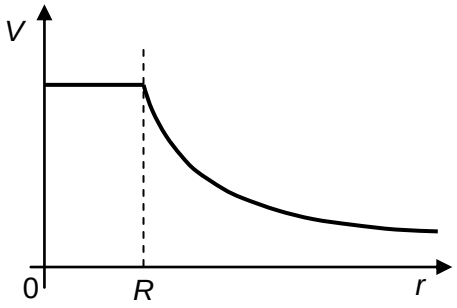
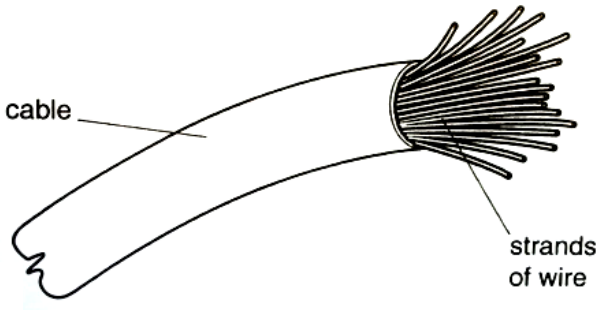


D



25 An insulated uniform wire is cut into n equal lengths to form an n-strand cable of resistance R.



What is the resistance of the original wire?

A R **B** nR **C** n^nR **D** n^2R

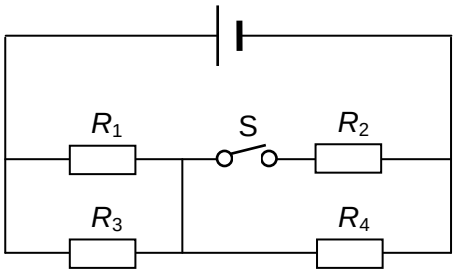
26 When a rechargeable battery is supplying a current of 3.0 A, the potential difference across its terminals is 8.5 V.

When the same battery is being recharged with a current of 2.0 A, the potential difference across its terminals is 11 V.

What is the internal resistance of the battery?

A 0.50 Ω **B** 2.5 Ω **C** 2.8 Ω **D** 5.5 Ω

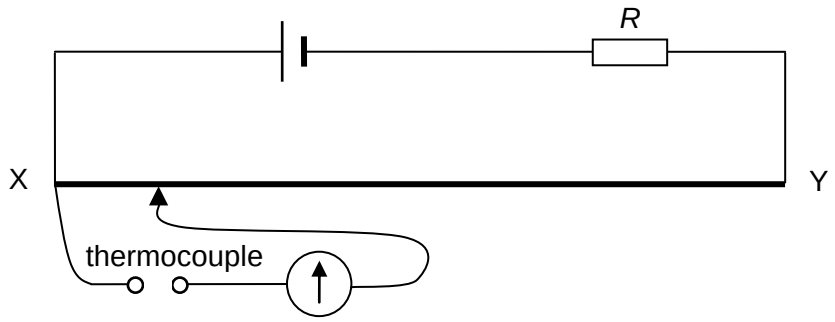
27 The diagram shows a network of identical resistors R_1, R_2, R_3 and R_4 connected to a battery of negligible internal resistance. When switch S is closed, the power dissipated by each resistor is P.



When switch S is opened, what are the powers dissipated by resistors R_1 and R_4?

	power dissipated by R_1	power dissipated by R_4
A	lower than P	greater than P
B	lower than P	lower than P
C	greater than P	greater than P
D	greater than P	lower than P

28 A simple potentiometer circuit is used to determine the small e.m.f. produced by a thermocouple.



The balance point is found to be near X. To improve the accuracy in the determination of the e.m.f., the balance point should be closer to Y.

How may this be achieved?

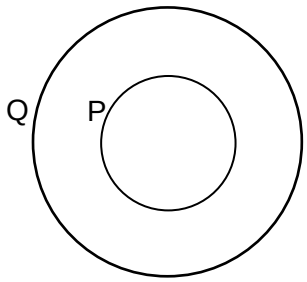
A Increase the resistance *R*.

B Decrease the resistance *R*.

C Connect a resistor in parallel with the thermocouple.

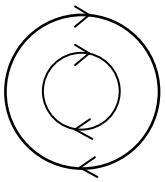
D Connect a resistor in series with the thermocouple.

29 Two circular coils P and Q, each of a single turn, have radii 0.10 m and 0.20 m respectively. They are arranged concentrically as shown. Coil P carries a current of 3.0 A, while coil Q carries 5.0 A. The magnetic flux density at the center of a single-turn circular coil is given by $B = \frac{\mu_o I}{2r}$, where I is the current in the coil of radius r and μ_o is the permeability of free space.

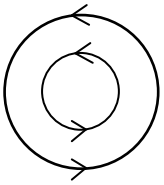


If the resultant magnetic flux density at the centre of the coils is $2.5\,\mu_o$, directed out of the page, which diagram shows the correct directions of the currents in the coils?

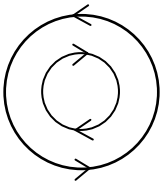
A



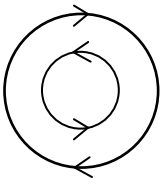
B



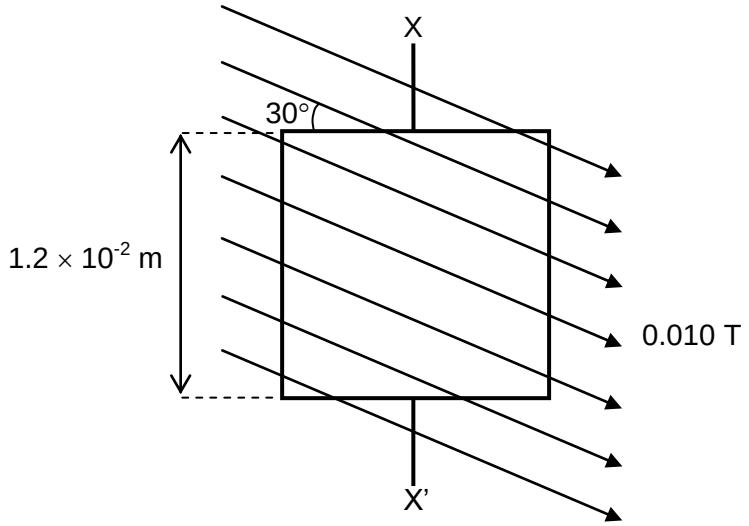
C



D



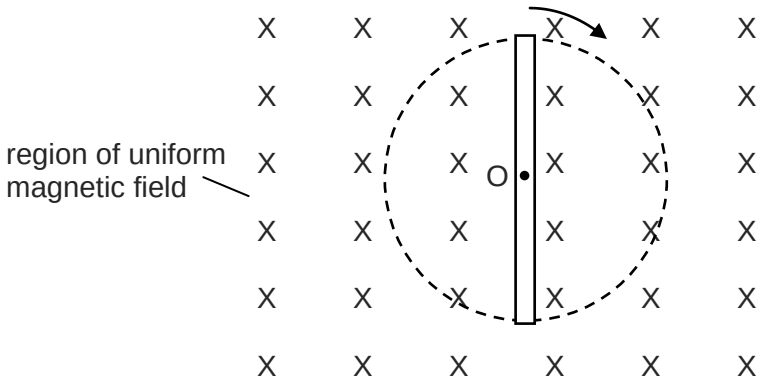
30 A square coil of 40 turns and sides 1.2×10^{-2} m is pivoted about the axis XX' through its centre as shown. A uniform magnetic field of flux density 0.010 T is in the plane of the coil and makes an angle of 30° to the horizontal sides of the coil.



What is the torque on the coil about the pivot when the current in the coil is 8.0 mA?

A 1.0×10^{-8} N m **B** 2.3×10^{-7} N m **C** 4.0×10^{-7} N m **D** 3.3×10^{-5} N m

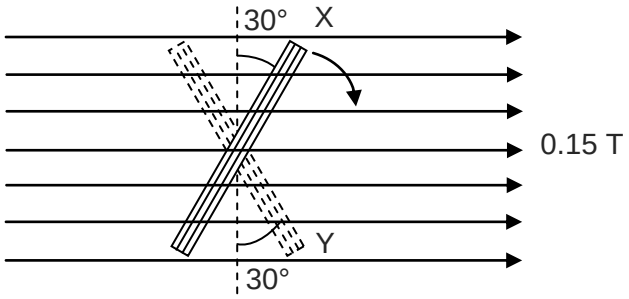
31 An aluminium rod of length 1.2 m spins at a constant rate of 20 revolutions per second about its centre O in a region of uniform magnetic field of flux density 0.25 T.



What is the magnitude of the induced e.m.f. between the ends of the rod?

A 0 V **B** 5.7 V **C** 23 V **D** 36 V

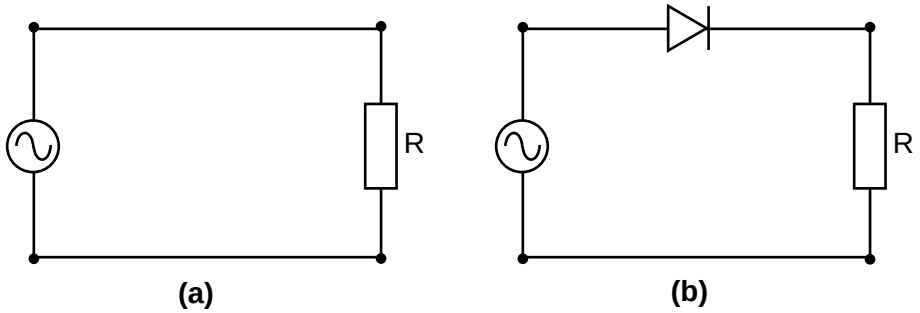
32 A coil of 10 turns and area 1.2 m^2 is rotated in a uniform magnetic field of flux density 0.15 T from position X to position Y in 2.0 s.



What is the average e.m.f. induced in the coil during the rotation?

A 0 V **B** 0.90 V **C** 1.6 V **D** 1.8 V

33 An a.c. supply of 120 V r.m.s. is connected to a resistor R as shown in circuit (a).



When a diode is added as shown in circuit (b), what should be the r.m.s. voltage of the a.c. supply in order to produce the same power output in R as circuit (a)?

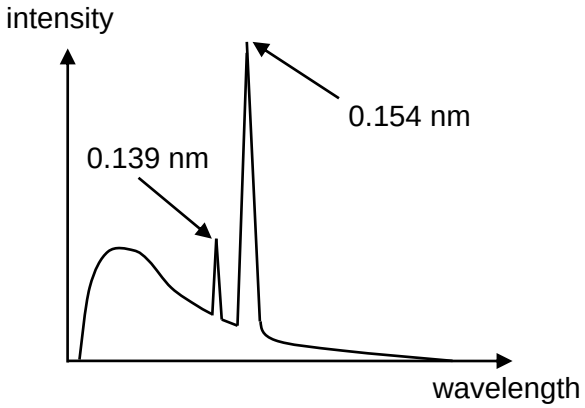
A $\frac{120}{\sqrt{2}}$ V **B** 120 V **C** $120\sqrt{2}$ V **D** 240 V

34 In an ideal transformer, the ratio of the secondary turns to the primary turns is 1:60. A 120 V a.c. source is connected to the primary coil and a 3.0 Ω resistor is connected to the secondary coil.

What is the current in the primary coil?

A 0.011 A **B** 0.67 A **C** 2.0 A **D** 40 A

35 The graph shows the X-ray spectrum of a copper target.



What is the velocity of the electrons incident on the copper target, if the wavelength of the K_α line is three times that of the most energetic X-ray emitted?

A 3.07×10^7 m s^{-1}

B 5.32×10^7 m s^{-1}

C 9.22×10^7 m s^{-1}

D 9.71×10^7 m s^{-1}

36 A microwave pulse lasts for 3.0×10^{-9} s. A photon of the microwave may be considered to be anywhere within this pulse, although the exact location is not known.

What is the uncertainty in the momentum of the photon?

A 5.9×10^{-35} kg m s^{-1}

B 1.2×10^{-34} kg m s^{-1}

C 3.7×10^{-34} kg m s^{-1}

D 7.4×10^{-34} kg m s^{-1}

37 Lasers emit coherent light because

A photons form a collimated beam of light.

B photons of the same phase are produced by spontaneous emissions.

C photons of the same energy are emitted when the electrons de-excite from a metastable state.

D photons produced by stimulated emissions are reflected by mirrors in the lasing medium.

38 Silicon, which has a small band gap, is used to make light dependent resistors.

Which of the following statements best describes how silicon might interact with photons to substantially reduce its resistivity?

A Conduction electrons absorb the energy of the photons and move faster.

B Valence electrons absorb the energy of the photons and cross the band gap into the conduction band.

C The conduction band absorbs the energy of the photons which causes the band gap to become smaller and allows more valence electrons to cross the gap into the conduction band.

D The valence band absorbs the energy of the photons which causes the band gap to become smaller and allows more valence electrons to cross the gap into the conduction band.

39 Two deuterium $\left({}^{2}_{1}\mathrm{H}\right)$ nuclei fuse together to form a helium-3 $\left({}^{3}_{2}\mathrm{He}\right)$ nucleus with the release of a neutron:

$$ {}^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{3}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n} $$

The binding energies per nucleon for:

$ {}^{2}_{1}\mathrm{H} $ is 1.09 MeV,
$ {}^{3}_{2}\mathrm{He} $ is 2.54 MeV.

How much energy is released in this reaction?

A 0.36 MeV **B** 1.45 MeV **C** 3.26 MeV **D** 5.44 MeV

40 The table shows the count rate recorded for a radioactive experiment at various times, with and without the radioactive source.

time / days	count rate / s^{-1}	
	with source	without source
7	134	12
14	113	13
21	98	14

What is the half-life of the radioactive source?

A 24 days **B** 26 days **C** 28 days **D** 31 days

End of Paper 1