NAME: _____ CLASS: _____ INDEX: _____

JC2 PRELIMINARY EXAMINATIONS
Higher 2

PHYSICS

9646/1
Paper 1
29 AUGUST 2016
1 h 15 mins

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name, tutorial group and index number on this cover page.

Write and/or shade your name, NRIC / FIN number and HT group on the Answer Sheet (OMR sheet),
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.

There are a total of **40 Multiple Choice Questions (MCQs)** in 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 Answer Sheet (OMR sheet) provided.

Read the instructions on the Answer Sheet 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.
Calculators may be used.

PHYSICS 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}
			$\approx (1/(36\pi)) \times 10^{-9}$ 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} mol^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

PHYSICS FORMULAE:

uniformly accelerated motion,	s	=	$u\,t + \frac{1}{2} a\,t^2$
	v^2	=	$u^2 + 2\,a\,s$
work done on / by a gas,	W	=	$p\,\Delta V$
hydrostatic pressure	P	=	$\rho g h$
gravitational potential,	ϕ	=	$-G\,m\,/\,r$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_0^2 - x^2}$
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	=	$Q\,/\,4\,\pi\,\varepsilon_0\,r$
alternating current / voltage,	x	=	$x_0 \sin \omega t$
transmission coefficient	T	=	$\exp(-2kd)$
	where k	=	$\sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{0.693}{t_{\frac{1}{2}}}$

1 The Van Der Waal's equation is used to describe the pressure, P, volume, V, and temperature, T, of a real gas,

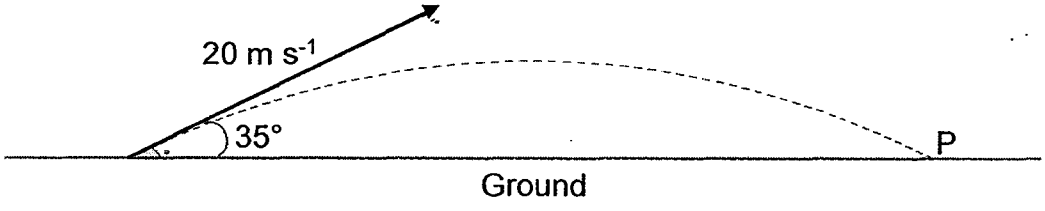
$$\left(P+\frac{n^2a}{V^2}\right)(V-nb)=nRT$$

where n is the number of moles of gas present and R is the universal gas constant. a and b are empirical constants.

What are the units of a and b respectively?

	Unit of *a*	**Unit of *b***
A	Pa m^6 mol^{-2}	m^3 mol^{-1}
B	mol^2 Pa^{-1} m^{-6}	mol m^{-3}
C	J m^2 mol^{-2}	J m^3 mol^{-1}
D	mol^2 J^{-1} m^{-2}	mol J m^{-3}

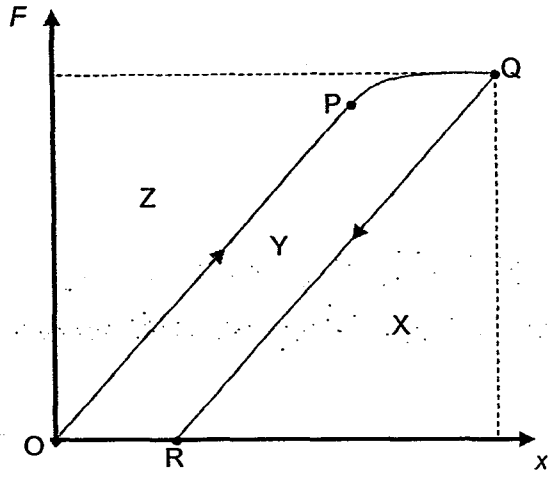
2 A student throws a stone 35° above the ground at an initial speed of 20 m s^{-1}. It travels in a projectile motion until it hits the ground at P with the same speed.



What is the magnitude of the change in velocity of the stone just before hitting the ground at P?

A 0.0 m s^{-1} **B** 20 m s^{-1} **C** 23 m s^{-1} **D** 33 m s^{-1}

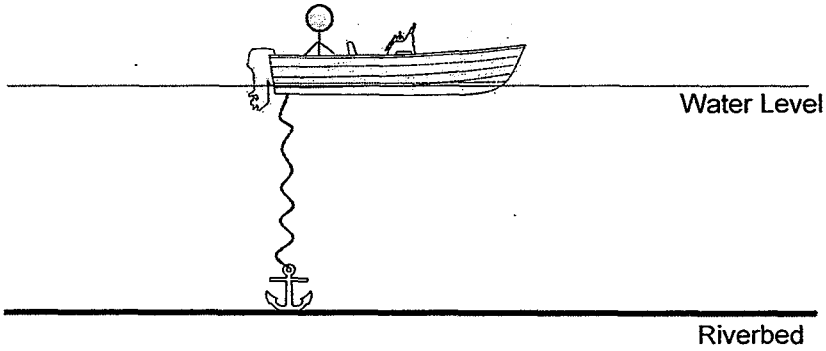
3 A metal wire is stretched by a varying force F, causing its extension x to increase as shown by the line OPQ on the graph. The force is then gradually reduced to zero and the relation between the force and extension is indicated by line QR.



Which area represents the elastic potential energy stored in the wire at Q?

A X B Y C Z D X + Y

4 The anchor of a small boat is initially completely submerged in water and resting on the riverbed.



What happens to the water level with respect to the boat when the fisherman first pulls the anchor up and when the anchor is finally on the small boat? Assume that the rope tied to the anchor is of negligible mass and volume.

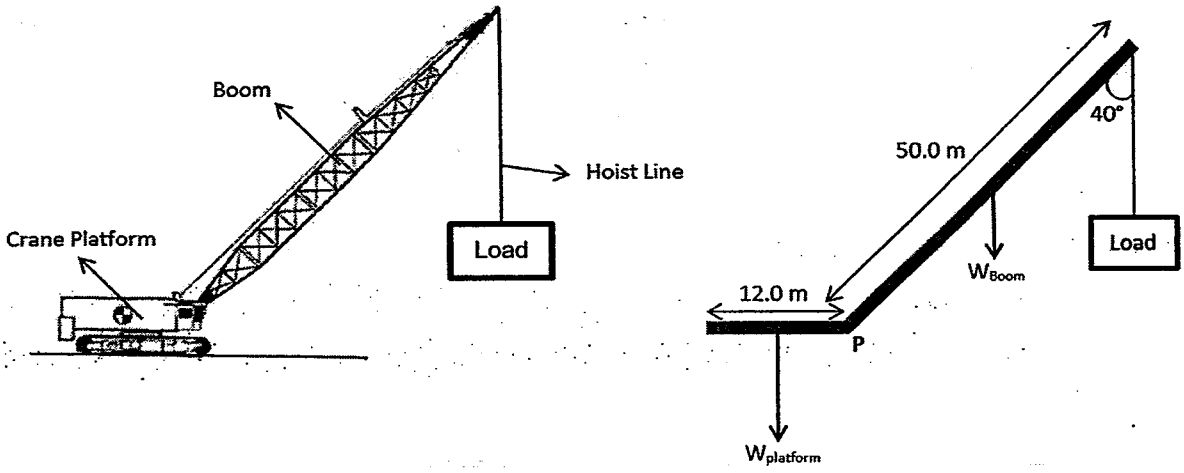
A The water level decreases when the fisherman first pulls the anchor up and then increases when the anchor is finally on the small boat.

B The water level increases when the fisherman first pulls the anchor up and then decreases when the anchor is finally on the small boat.

C The water level increases when the fisherman first pulls the anchor up and then increases further when the anchor is finally on the small boat.

D The water level decreases when the fisherman first pulls the anchor up and then decreases further when the anchor is finally on the small boat.

5 A crane starts to lift a load of 5.80×10^4 kg load from the ground.

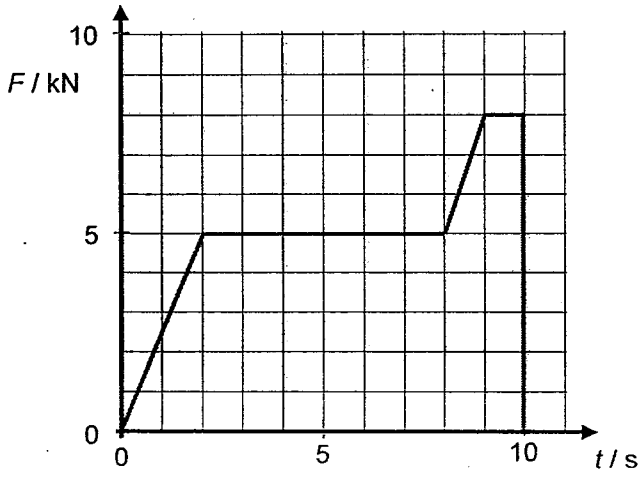


The diagram on the right is a simplified schematic representation of the crane and load on the left.

If the platform has a uniform mass of 4.00×10^5 kg and the boom has a uniform mass of 4.00×10^4 kg what is the maximum mass that the crane can lift vertically at constant speed at the end of the boom without the crane toppling over at point P?

A 2.80×10^4 kg **B** 4.27×10^4 kg **C** 4.40×10^4 kg **D** 5.47×10^4 kg

6 The following graph describes the variation of the resultant force F on an object of mass 2500 kg with time t until 10 s.



If the object is initially at rest when $t = 0$ s, what is the object's speed at $t = 8$ s?

A 14 m s^{-1} **B** 16 m s^{-1} **C** 18 m s^{-1} **D** 20 m s^{-1}

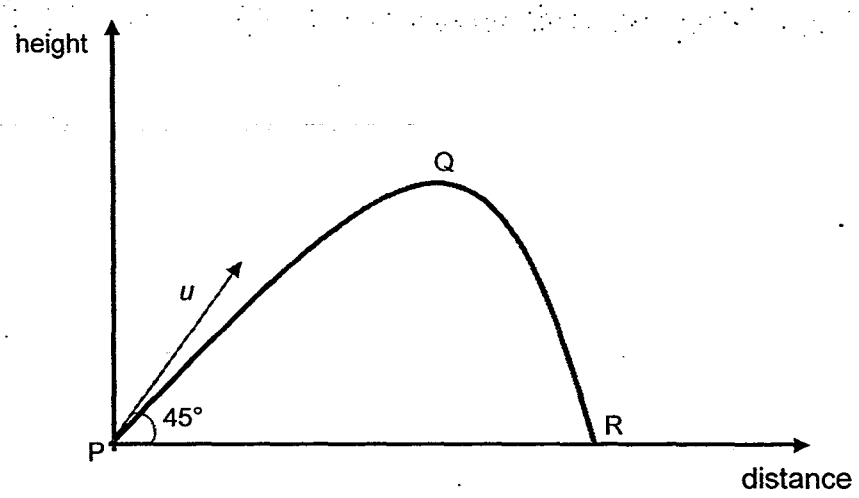
7 An object falls freely from rest vertically to the ground. The effects of air resistance on the object are negligible.

The object travels 60 % of the total vertical distance to the ground in the last second of its fall.

What is the total vertical distance?

A 1.8 m **B** 2.1 m **C** 36 m **D** 71 m

8 An object is projected with a certain speed u at an angle of 45° to the horizontal from the ground at point P. It travels through air with significant drag force on it, reaches the maximum height at Q, falls and hits the ground at a certain distance away at R.



Which of the following statement is true?

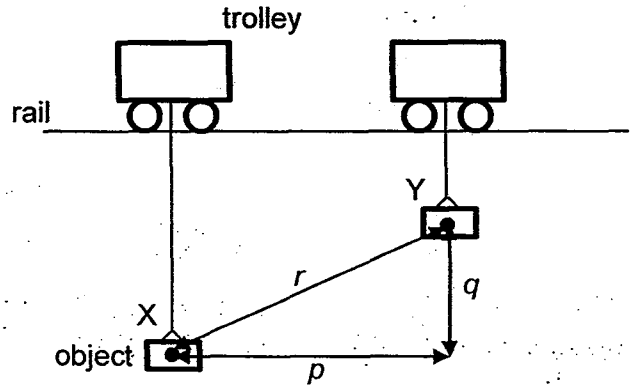
A The time taken for the object to travel from P to Q is more than the time taken for it to travel from Q to R.

B The time taken for the object to travel from P to Q is less than the time taken for it to travel from Q to R.

C The time taken for the object to travel from P to Q is the same as the time taken for it to travel from Q to R.

D The time taken for the object to travel from P to Q can be the same as or more or less than the time taken for it to travel from Q to R, depending on speed u.

9 An object of weight W hangs from a trolley that runs along a rail. The trolley moves horizontally through a distance p and simultaneously raises the object through a height q.



As a result, the object moves through a distance r from X to Y. It starts and finishes at rest.

Which of the following statements about the object during this process **must** be correct?

A The work done on the object is Wr.

B The net work done on the object is 0.

C The gravitational potential energy at Y is Wq.

D The increase in kinetic energy of the weight is $W(p + q)$.

10 The data below are taken from a test of a petrol engine for a motor car.

power output	150 kW
fuel consumption	20 litres per hour
energy content of fuel	40 MJ per litre

Which expression will evaluate the efficiency of the engine?

A $\dfrac{150 \times 10^3}{40 \times 10^6 \times 20 \times 60 \times 60}$

B $\dfrac{150 \times 10^3 \times 60 \times 60}{20 \times 40 \times 10^6}$

C $\dfrac{150 \times 10^3 \times 40 \times 10^6 \times 20}{60 \times 60}$

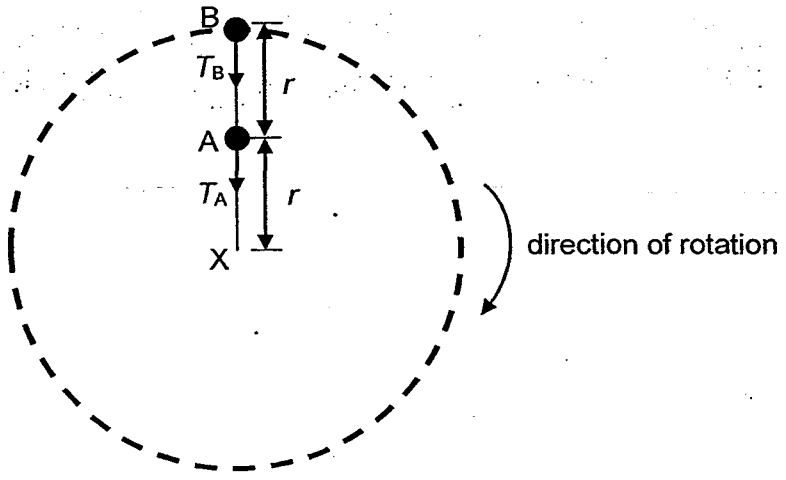
D $\dfrac{150 \times 10^3 \times 20}{40 \times 10^3 \times 60 \times 60}$

11 Two toy cars are set to run round a circular track of radius 80 m. Each of them moves at a constant speed. At time *t*, car A overtakes car B. 4 minutes later, car A passes B again for the second time.

What is the period of car A, if the period of car B was 60 seconds?

A 15 s **B** 48 s **C** 120 s **D** 240 s

12 Two spheres A and B of equal mass, *m*, are attached on a string which moves in a vertical circular motion. A is at a distance *r* while B is 2*r* away from the end of the string X as shown in the figure below.



The tensions in each part of the strings are T_A and T_B respectively.

Which of the following statements about the forces acting on objects A and B are correct?

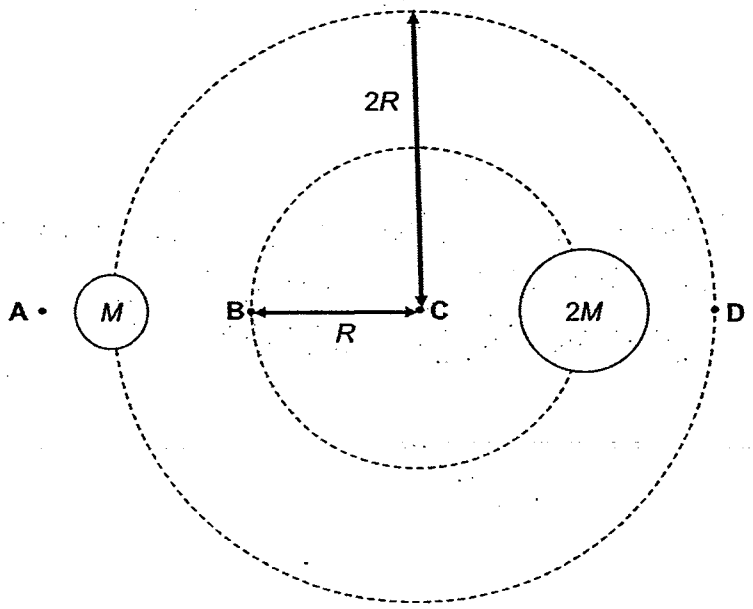
A The magnitude of T_A and T_B are always constant.

B Throughout the motion, the net force acting on sphere A is only T_A.

C For the objects to execute circular motion T_B can have a magnitude of zero.

D The magnitude of T_A and T_B are always equal as they are action reaction forces.

13 Two binary stars of masses M and $2M$ revolve about their common centre of mass in orbits of radius $2R$ and R respectively.



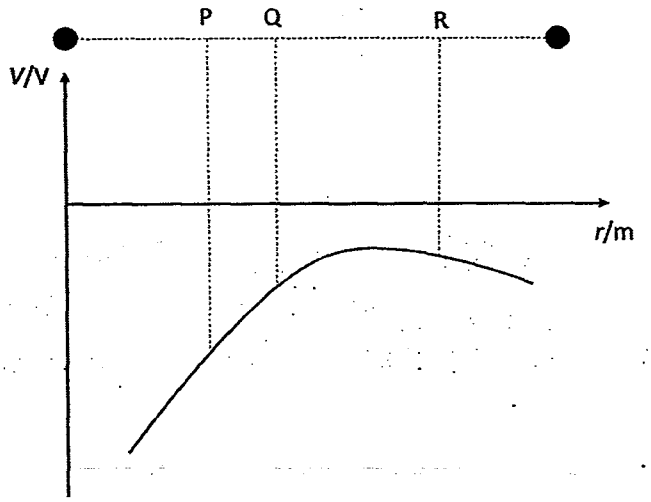
At which point does the gravitational field strength have the lowest magnitude?

14 On October 19 2016, the spacecraft *Juno* will enter into a circular polar orbit with a period of 14 days around the planet Jupiter which has a mass of 1.90×10^{27} kg.

What is the radius of *Juno's* orbit?

A 8.64×10^{4} m **B** 1.67×10^{9} m **C** 6.29×10^{17} m **D** 4.69×10^{27} m

15 Two charges are placed in free space. The variation of the electric potential V, with the distance r from the left charge along the line joining the centres of the charges is shown below.



Which of the following statements is true?

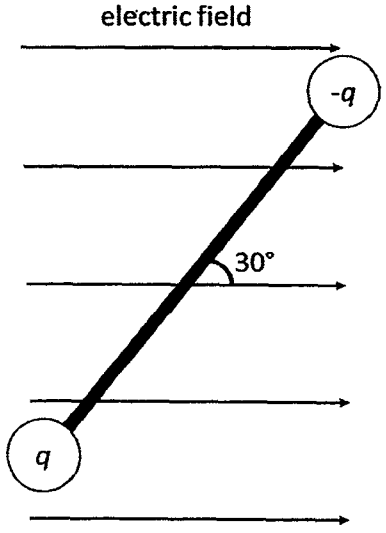
A Any charge placed at point P will experience a resultant force towards the left.

B The electric field strength at point Q is larger than the electric field strength at P.

C Net positive work needs to be done by an external agent to move a negative charge from point R to point P.

D A positive charge at P has more electric potential energy as compared to an identical positive charge placed at R.

16 Two charges of electric charge q and $-q$ connected by a light electrically insulated rigid rod of length L are placed in a uniform electric field of electric field strength E as shown in the figure.



Which of the following is the correct expression for the torque due to the couple?

A $\frac{qEL}{2}$

B qEL

C $2qEL$

17 An object moving in simple harmonic motion has a maximum velocity v_0 and an amplitude x_0.

What is its velocity, in terms of v_0, when it is at a distance $0.25x_0$ from its amplitude position?

A $0.13v_0$

B $0.25v_0$

C $0.66v_0$

D $0.75v_0$

18 Some doors use a spring system to ensure the door closes again after it is opened. These springs are usually damped.

If the spring used causes critical damping in the door, which of the following will happen when the door is opened?

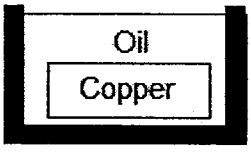
A The door will quickly swing shut without oscillating.

B The door will continue to swing back and forth for a long time.

C The door will take a long time to swing shut without oscillating.

D The door will swing back and forth, but will come to a stop eventually.

19 A copper block at 500 °C is cooled in an oil bath that was initially at 20 °C.



Using the ratios below, calculate the temperature at thermal equilibrium. Assume no heat transfer with the surroundings and the container.

$$\frac{\text{density of oil}}{\text{density of copper}} = 0.110$$

$$\frac{\text{specific heat capacity of oil}}{\text{specific heat capacity of copper}} = 4.29$$

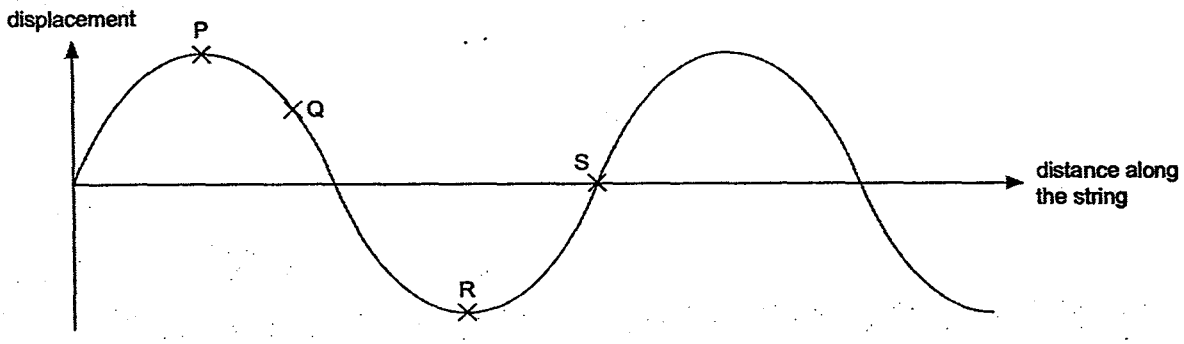
$$\frac{\text{volume of oil bath}}{\text{volume of copper}} = 10.0$$

A 41.6 °C **B** 104 °C **C** 160 °C **D** 416 °C

20 The temperature of an ideal gas is raised from 32.1 °C to 40.5 °C. What is the percentage increase in the r.m.s. speed of its gas particles?

A 1.4% **B** 2.8% **C** 12% **D** 13%

21 The figure shows the shape at a particular instant of part of a transverse wave travelling from left to right along a string.



Which statement about the motion of elements of the string at this instant is correct?

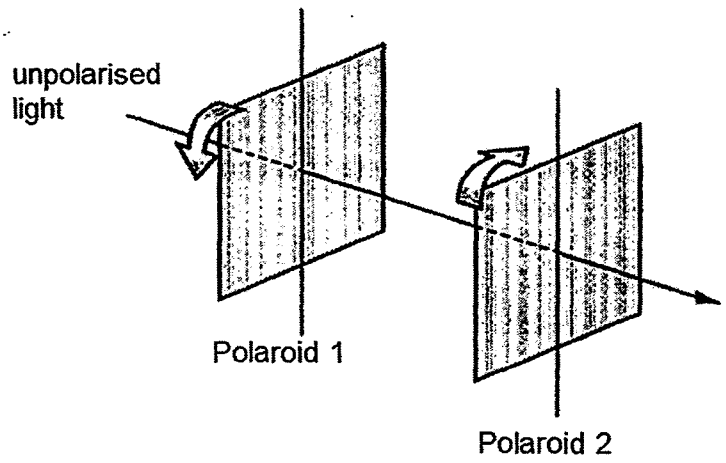
A The speed of Q is higher than S.

B Both Q and S are moving upwards.

C The energy of P and S is entirely kinetic.

D The acceleration of P and R is a maximum.

22 The diagram shows a beam of initially unpolarised light passing through two Polaroid filters.

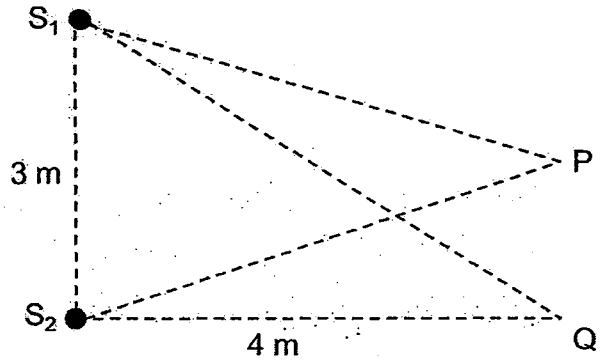


The transmitting axes of these filters are initially aligned. The two filters are now rotated through 360° in opposite directions in their own plane at equal speeds.

How many maxima of intensity occur in the light emerging from the Polaroid on the right?

A 2 **B** 3 **C** 5 **D** 9

23 Two sources of waves, S_1 and S_2, are situated as shown in the figure below. Individually, each source emits waves of intensity I.



Equidistant from S_1 and S_2, a detector at P registers a steady minimum wave intensity. The same detector registers the next steady minimum intensity when it moves to point Q. Which of the following statements is false about the two sources of waves?

A The two sources of waves are coherent.

B The two sources of waves have the same amplitude.

C The two sources of waves have a similar wavelength of 2 m.

D The two sources of waves have a phase difference of π radians.

24 Monochromatic light is incident normally on a diffraction grating and first order diffraction is observed at an angle of 28.6°.

Which of the following statements about the diffraction pattern produced by the grating is true?

A The second order image is observed at 57.2° and there is a total of 3 intensity maxima formed on the screen.

B The second order image is observed at 57.2° and there is a total of 5 intensity maxima formed on the screen.

C The second order image is observed at 73.2° and there is a total of 5 intensity maxima formed on the screen.

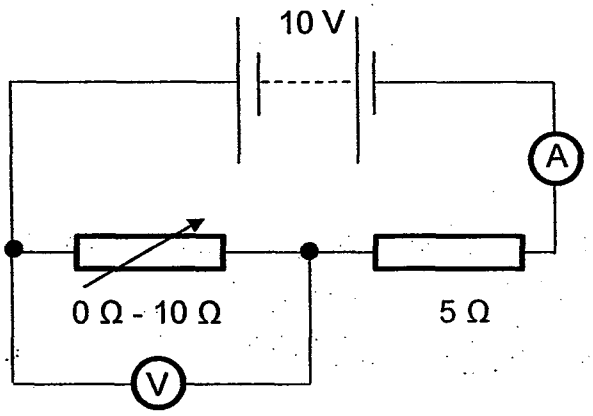
D The second order image is observed at 73.2° and there is a total of 7 intensity maxima formed on the screen.

25 The potential difference across an electrical component is 20 V. The time taken for charge carriers to move through this component is 15 s, and, in this time, the energy of the charge carriers changes by 12 J.

What is the electrical resistance of this component?

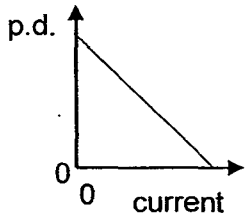
A 0.040 Ω **B** 0.80 Ω **C** 33 Ω **D** 500 Ω

26 A 10 V battery is in series with an ammeter, a 5 Ω fixed resistor and a 0 - 10 Ω variable resistor. A high-resistance voltmeter is connected across the variable resistor.

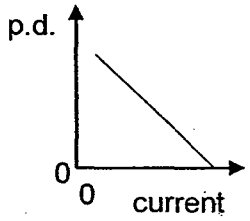


The resistance of the variable resistor is changed from zero to its maximum value.

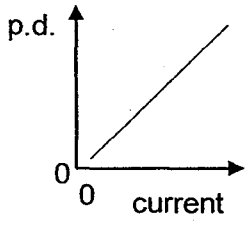
Which graph shows how the potential difference (p.d.) measured by the voltmeter varies with the current measured by the ammeter?



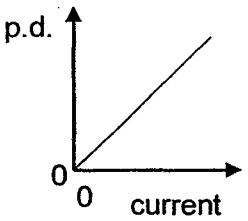
A



B

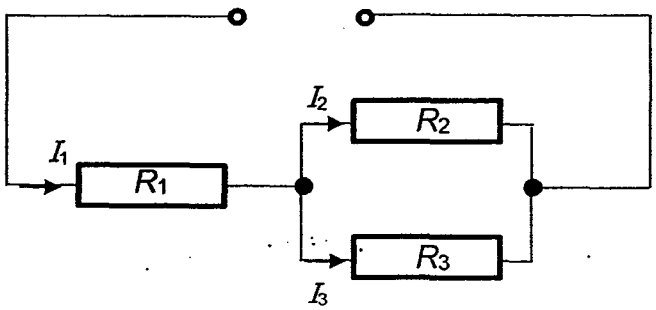


C



D

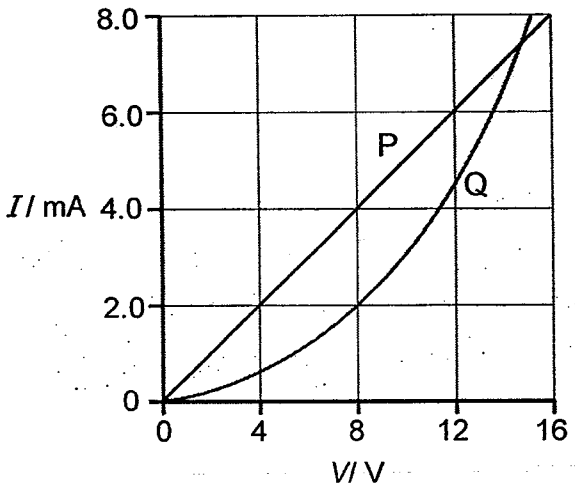
27 The circuit diagram shows three fixed resistors R_1, R_2 and R_3 connected to a power supply. The currents flowing through each of these resistors are I_1, I_2 and I_3 respectively.



Which of the following expression represents the ratio of $\frac{R_2}{R_3}$?

A $\frac{I_2}{I_3}$ **B** $\frac{I_1}{I_3} - 1$ **C** $\frac{I_1}{I_2} - 1$ **D** $1 + \frac{I_3}{I_2}$

28 The *I*-V characteristics of two electrical components P and Q are shown below.



Which statement is correct?

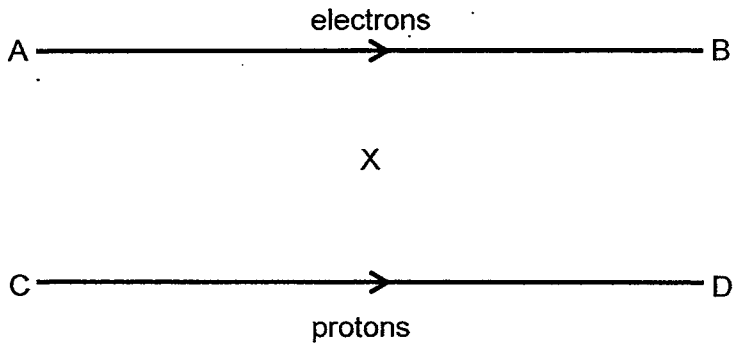
A P is a resistor and Q is a filament lamp.

B The ratio $\frac{\text{resistance of P}}{\text{resistance of Q}}$ is always less than 1.

C At 2.0 mA the power dissipated through Q is always twice that of P.

D At the point where the two lines intersect the resistance of Q is approximately twice that of P.

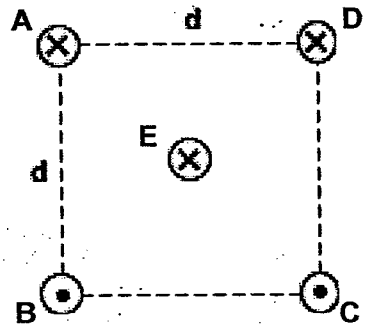
29 A beam of electrons in AB and another made out of protons in CD are parallel to each other.



The rate of proton flow in CD is twice that of the electrons in AB. What direction is the magnetic field at point X, which is equidistant from AB and CD?

A Towards AB **B** Towards CD **C** Into the page **D** Out of the page

30 Five straight and parallel wires are arranged as shown in the diagram below, and each carries a steady current I.



Which of the following statements incorrectly describes the above scenario?

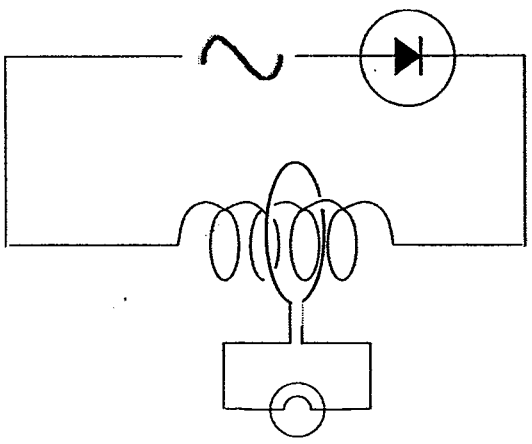
A The resultant force on wire E due to wires A, B, C and D is pointing towards line AD, perpendicular to AD.

B The resultant force on wire E due to wires B and C is pointing towards line AD, perpendicular to AD.

C The resultant force on wire E due to wires A and D is pointing towards line AD, perpendicular to AD.

D The resultant force on wire E due to wires B and D is pointing towards line AD, perpendicular to AD.

31 A circuit containing a circular loop of wire connected to a low power light bulb is positioned around a solenoid connected to a sinusoidal AC source and a diode as shown in the diagram below.



Which of the following statements is true?

A The light bulb lights up because the magnetic flux linkage through the loop varies with time.

B The light bulb lights up because the magnetic flux linkage through the loop reverses its direction every cycle.

C The light bulb does not light up because the magnetic flux linkage through the loop does not reverse its direction.

D The light bulb does not light up because the diode prevents current from flowing and thus producing any magnetic flux in the solenoid.

32 Two coils are linked by a soft iron bar as shown in Fig. A. A current source is connected to the primary coil. The primary current I_p varies with time as shown by the Fig. B.

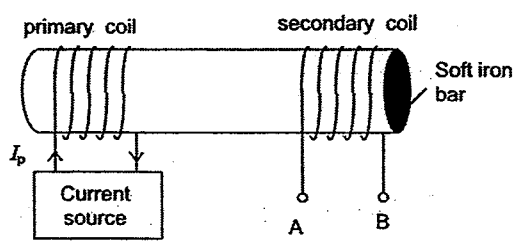


Fig. A

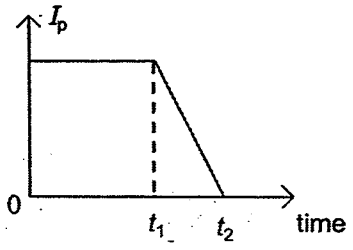
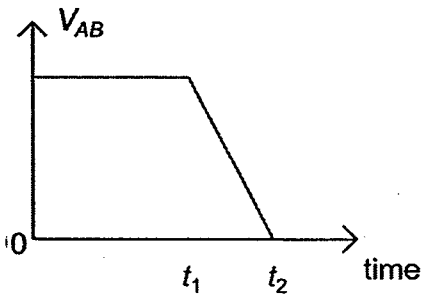


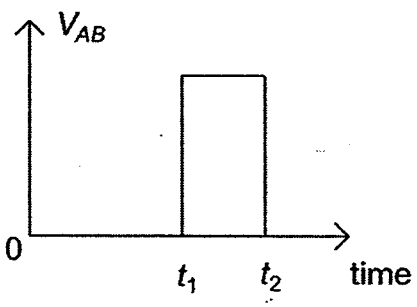
Fig. B

Which of the following sketches represents the variation of the voltage across the secondary coil V_{AB} with time?

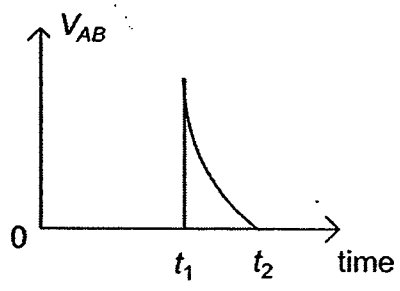
A



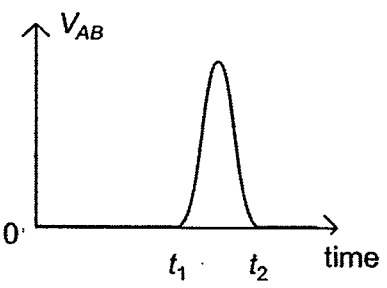
B



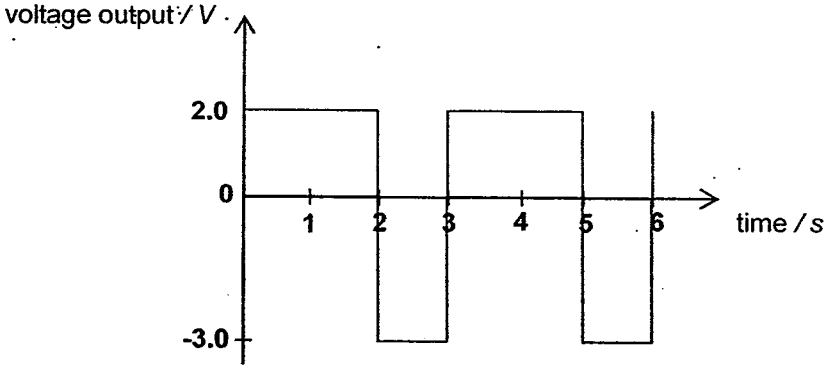
C



D



33 A 20 Ω resistor is connected to an AC power supply with a voltage output that varies from 2.0 V to -3.0 V as shown on the graph below.



What is the average heating power dissipated in the resistor?

A 0.083 W B 0.28 W C 0.42 W D 0.65 W

34 Which of the following statements about the wave-particle duality is true?

A The wave-particle duality suggests that every particle will have an associated wavelength when it moves, provided that it is subatomic in size.

B The wave-particle duality suggests that every particle will have an associated wavelength when it moves, regardless of whether it has a mass or not.

C The wave-particle duality suggests that every particle will have an associated wavelength when it moves, provided that they have a non-zero charge.

D The wave-particle duality suggests that every particle will have an associated wavelength when it moves, provided that it is undergoing quantum tunneling.

35 The fastest recorded tennis serve was measured to have a speed of (73.2 ± 0.1) m s^{-1} and an average tennis ball has a mass of 58.0 g.

What is the minimum uncertainty of its position?

A 9.09×10^{-33} m **B** 1.24×10^{-35} m **C** 9.09×10^{-36} m **D** 1.24×10^{-38} m

36 Which of the following changes will increase the probability of a particle tunnelling through a potential barrier?

A Increasing the width of the potential barrier

B Increasing the height of the potential barrier

C Shooting particles of a smaller mass at the potential barrier

D Decreasing the energy of the particles incident on the potential barrier

37 Which of the following best describes the meaning of population inversion?

A Electrons are able to stay in such a state for a longer period.

B An atom in an excited state undergoes a transition to the ground state and emits a photon.

C The number of atoms at a lower energy state exceeds the number of atoms at a higher energy state.

D The number of atoms at a higher energy state exceeds the number of atoms at a lower energy state.

38 Which of the following statements about a semiconductor diode in forward bias is incorrect?

A Holes will move away from the p-n junction due to the external electric field.

B Electrons in the n-type semiconductor will cross steadily to the p-type semiconductor.

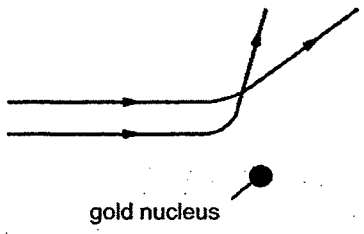
C The applied potential difference from the external source of e.m.f. opposes the junction potential.

D The n-type material of the diode is connected to the negative terminal of the external source of e.m.f.

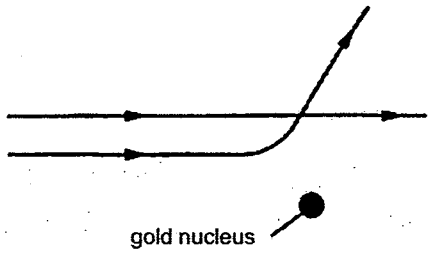
39 Two alpha particles with equal energies are fired towards the nucleus of a gold atom.

Which diagram could represent their path?

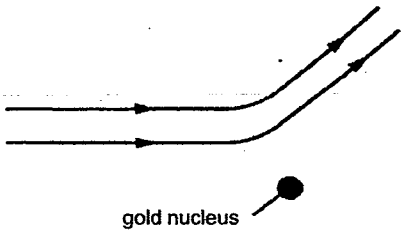
A



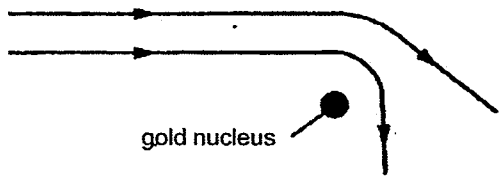
B



C



D



40 A newly prepared radioactive nuclide has a decay constant of 10^{-6} s^{-1}.

What is the approximate half-life of the nuclide?

A 1 hour

B 1 day

C 1 week

D 1 month

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NAME: _____ CLASS: _____ INDEX: _____

JC2 MID YEAR EXAMINATIONS
Higher 2

PHYSICS [SOLUTIONS]

9646/1
Paper 1
29 AUGUST 2016
1 h 15 mins

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name, tutorial group and index number on this cover page.

Write and/or shade your name, NRIC / FIN number and HT group on the Answer Sheet (OMR sheet),
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.

There are a total of **40 Multiple Choice Questions (MCQs)** in 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 Answer Sheet (OMR sheet) provided.

Read the instructions on the Answer Sheet 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.
Calculators may be used.

PHYSICS 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}
			$\approx (1/(36\pi)) \times 10^{-9}$ 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} mol^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

PHYSICS FORMULAE:

uniformly accelerated motion,	s	=	$u t + \frac{1}{2} a t^2$
	v^2	=	$u^2 + 2 a s$
work done on / by a gas,	W	=	$p \Delta V$
hydrostatic pressure	P	=	$\rho g h$
gravitational potential,	ϕ	=	$-G m / r$
displacement of particle in s.h.m.	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_0 \cos \omega t$
		=	$\pm \omega \sqrt{x_0^2 - x^2}$
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	=	$Q / 4 \pi \varepsilon_0 r$
alternating current / voltage,	x	=	$x_0 \sin \omega t$
transmission coefficient	T	=	$\exp(-2kd)$
	where k	=	$\sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{0.693}{t_{\frac{1}{2}}}$

express derived units as products or quotients of the base units and use the named units listed in 'Summary of Key Quantities, Symbols and Units' as appropriate. L2

The Van Der Waal's equation is used to describe the pressure, P, volume, V, and temperature, T, of a real gas,

$$\left(P+\frac{n^2a}{V^2}\right)(V-nb)=nRT$$

where n is the number of moles of gas present and R is the universal gas constant. a and b are empirical constants.

What are the units of a and b respectively?

	Unit of *a*	Unit of *b*
A	Pa m^6 mol^{-2}	m^3 mol^{-1}
B	mol^2 Pa^{-1} m^{-6}	mol m^{-3}
C	J m^2 mol^{-2}	J m^3 mol^{-1}
D	mol^2 J^{-1} m^{-2}	mol J m^{-3}

Answer: A

As all terms separated with "+" or "-" have the same units,

$[P]=\left[\frac{n^2a}{V^2}\right]$

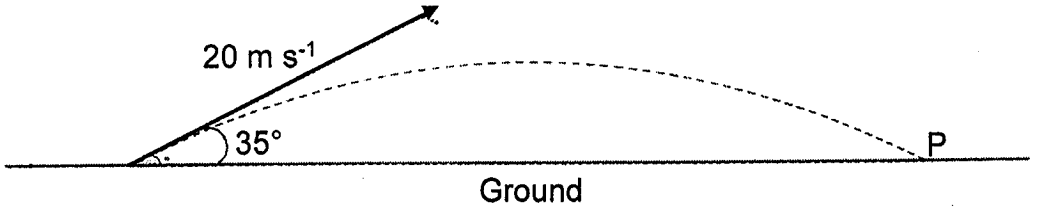
$[a]=$ Pa m^6 mol^{-2}

$[V]=[nb]$

$[b]=$ m^3 mol^{-1}

add and subtract coplanar vectors. L2

A student throws a stone 35° above the ground at an initial speed of 20 m s^{-1}. It travels in a projectile motion until it hits the ground at P with the same speed.



What is the magnitude of the change in velocity of the stone just before hitting the ground at P?

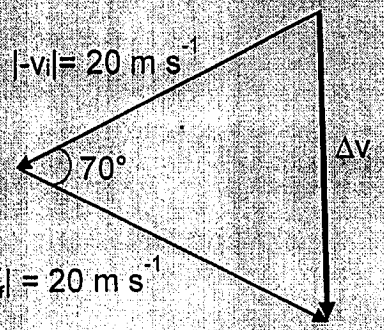
A 0.0 m s^{-1} **B** 20 m s^{-1} **C** 23 m s^{-1} **D** 33 m s^{-1}

Answer: C

Change in velocity,

$\Delta v = v_f - v_i$

$\Delta v = v_f + (-v_i)$

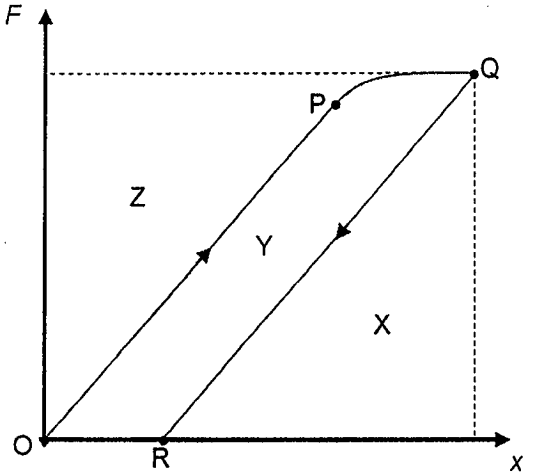


$\Delta v = \sqrt{(20)^2 + (20)^2 - 2(20)(20)\cos 70°}$

$\Delta v = 23 \text{ m s}^{-1}$

A metal wire is stretched by a varying force *F*, causing its extension *x* to increase as shown by the line OPQ on the graph. The force is then gradually reduced to zero and the relation between the force and extension is indicated by line QR.

deduce the elastic potential energy in a deformed material from the area under the force extension graph. L2



Which area represents the elastic potential energy stored in the wire at Q?

A X **B** Y **C** Z **D** X + Y

Answer: D

The total elastic potential energy stored at Q before decreasing the force *F* is the total area under the graph X+Y.

Area X is the recoverable energy from the spring.

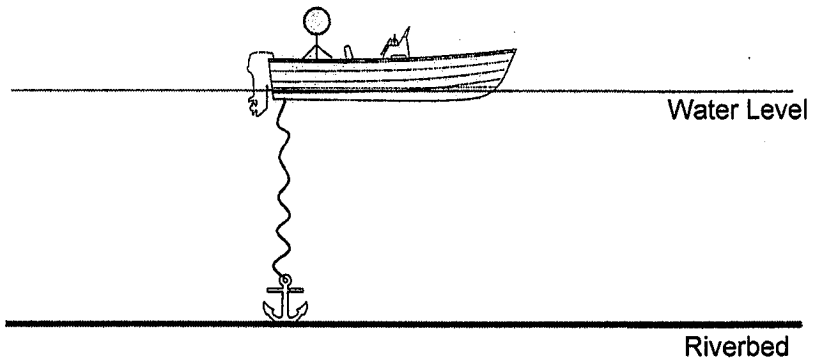
Area Y is the net work done on the spring when the extension returns to point R.

Area Z has no meaning currently.

The anchor of a small boat is initially completely submerged in water and resting on the riverbed.

recall and apply the principle that for an object floating in equilibrium the upthrust is equal to the weight of the object to new L3

situations or to solve related problems.



What happens to the water level with respect to the boat when the fisherman first pulls the anchor up and when the anchor is finally on the small boat? Assume that the rope tied to the anchor is of negligible mass and volume.

A The water level decreases when the fisherman first pulls the anchor up and then increases when the anchor is finally on the small boat.

B The water level increases when the fisherman first pulls the anchor up and then decreases when the anchor is finally on the small boat.

C The water level increases when the fisherman first pulls the anchor up and then increases further when the anchor is finally on the small boat.

D The water level decreases when the fisherman first pulls the anchor up and then decreases further when the anchor is finally on the small boat.

Answer: C

The water level with respect to the boat indicates the upthrust on the boat. When the water level is high, the upthrust on the boat is high and vice versa (Archimedes' Principle).

When the anchor is resting on the riverbed, the rope is not taut. Hence, the upthrust on the boat only supports the boat and the fisherman.

When the fisherman is pulling the anchor up at a constant speed, the force on the boat by the rope, which is numerically equal to the tension of the rope, T, acts downwards. As the new upthrust on the boat takes into account the additional force so that the boat can remain afloat, the boat will displace more fluid, hence water level increases.

By Newton 2nd law, taking upward as positive, during the ascending of the anchor, the resultant force on the anchor, (U – upthrust, W – weight of anchor)

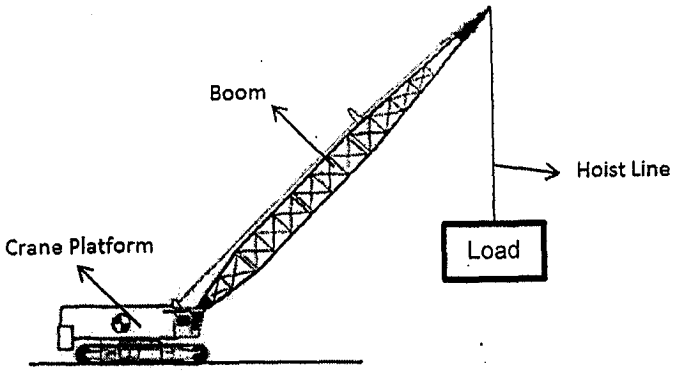
$$\sum F = U + T - W = 0$$

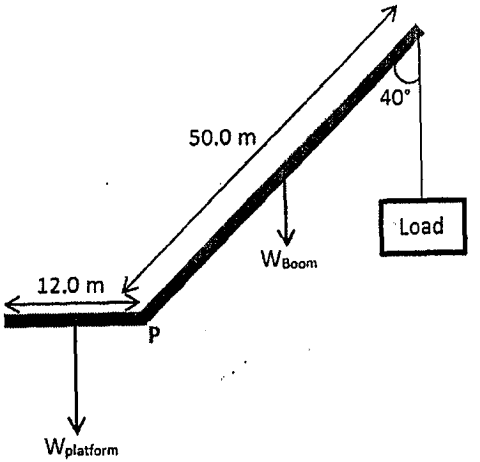
$$T = W - U \text{ -(1)}$$

When the anchor is out of the water and on the boat, the new upthrust on the boat takes into account the additional full weight of the anchor. Therefore, comparing with equation 1, where T, which is less than W, is the additional force on the boat. Therefore, the new water level will increase further as it takes into account a larger magnitude of the weight of the anchor.

apply the principle of moments to new situations or to solve related problems L2

A crane starts to lift a load of 5.80 × 104 kg load from the ground.





The diagram on the right is a simplified schematic representation of the crane and load on the left.

If the platform has a uniform mass of 4.00×10^5 kg and the boom has a uniform mass of 4.00×10^4 kg what is the maximum mass that the crane can lift vertically at constant speed at the end of the boom without the crane toppling over at point P?

A 2.80×10^4 kg **B** 4.27×10^4 kg **C** 4.40×10^4 kg **D** 5.47×10^4 kg

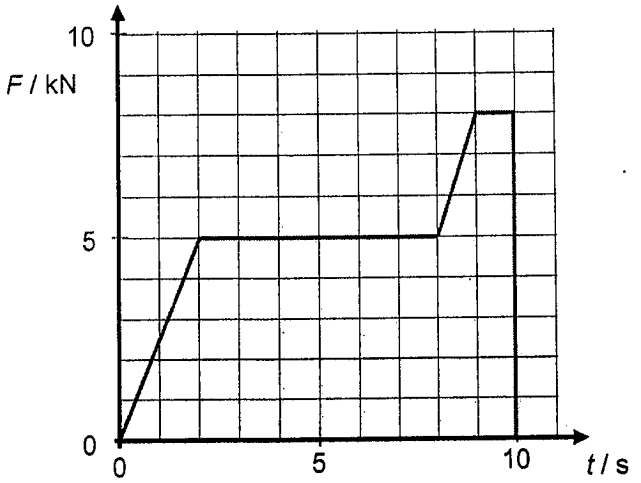
Answer: D

Maximum weight before toppling over is when the force acting on the crane by the ground is solely acting at point P.

By principle of moments and taking turning point at P,
Clockwise moment = Anticlockwise moment
$4.00\times10^4\times25.0\sin40°\times 9.81 + M_{load}\times50.0\sin40°\times9.81 = 4.00\times10^5\times6\times9.81$
$M_{load} = 5.467\times10^4 = \mathbf{5.47\times10^4}$ **kg**

The following graph describes the variation of the resultant force F on an object of mass 2500 kg with time t until 10 s.

define linear momentum and impulse L2



If the object is initially at rest when t = 0 s, what is the object's speed at t = 8 s?

A 14 m s^{-1} **B** 16 m s^{-1} **C** 18 m s^{-1} **D** 20 m s^{-1}

Answer: A
The area under a F-t graph gives the impulse of the object. Since the value of the impulse is numerically equal to the change in momentum of the object, at t = 8 s,

$\Delta p = p_f - p_i$

$p_f - 0 = \Delta p$

$v_f = \dfrac{\frac{1}{2}(2)(5\times10^3) + (6)(5\times10^3)}{2500}$

$v_f = 14 \text{ m s}^{-1}$

An object falls freely from rest vertically to the ground. The effects of air resistance on the object are negligible.

The object travels 60 % of the total vertical distance to the ground in the last second of its fall.

What is the total vertical distance?

solve problems using equations which represent uniformly accelerated motion in a straight line, including the motion of bodies falling in a uniform gravitational field without air resistance. L3

A 1.8 m **B** 2.1 m **C** 36 m **D** 71 m

Answer: C

Let the total distance be d
Taking downward as positive, for the last second of the motion,

$s = ut + \frac{1}{2}at^2$

$0.6d = v(1) + \frac{1}{2}a(1)^2$

A change to symbol v as the velocity at the start of the second part of the motion is the final velocity v of the first part of the motion.

$v = 0.6d - \frac{1}{2}a \quad \text{--(1)}$

For the first part of the motion,

$v^2 = u^2 + 2as$

$v^2 = 0 + 2a(0.4d)$

$v^2 = 0 + 0.8ad \quad \text{--(2)}$

Substitute (1) in (2),

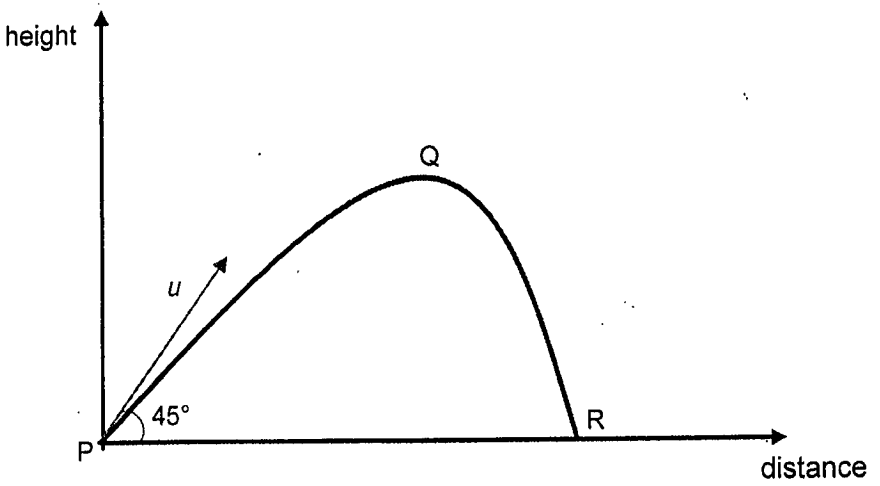
$$0.36d^2 + \frac{1}{4}a^2 - 1.4ad = 0$$

$$d = \frac{-(-1.4a) \pm \sqrt{(-1.4a)^2 - 4(0.36)\left(\frac{1}{4}a^2\right)}}{2(0.36)}$$

$d = 36.3$ m. (Reject $d = 1.84$m, as the time taken for the total distance of 1.84 m is only 0.61 s, did not meet the description of the question, 60 % of the total distance in the last second.)

describe qualitatively the motion of bodies falling in a uniform gravitational field with air resistance. L2

An object is projected with a certain speed u at an angle of 45° to the horizontal from the ground at point P. It travels through air with significant drag force on it, reaches the maximum height at Q, falls and hits the ground at a certain distance away at R.



Which of the following statement is true?

A The time taken for the object to travel from P to Q is more than the time taken for it to travel from Q to R.

B The time taken for the object to travel from P to Q is less than the time taken for it to travel from Q to R.

C The time taken for the object to travel from P to Q is the same as the time taken for it to travel from Q to R.

D The time taken for the object to travel from P to Q can be the same as or more or less than the time taken for it to travel from Q to R, depending on speed *u*.

Answer: B

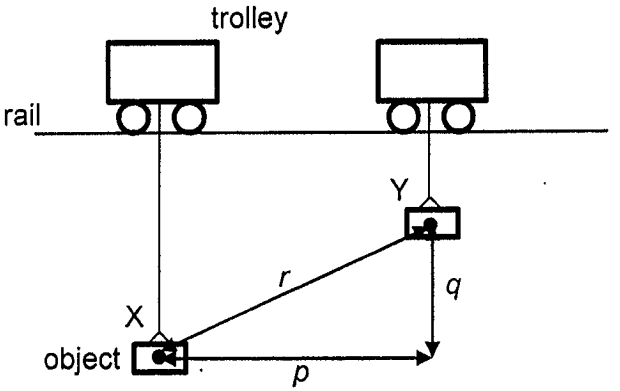
The object moves through with a drag force in both vertical and horizontal direction.

In the horizontal direction, the horizontal velocity will reduce to zero, thus showing the shorter range from Q to R, giving the false impression that the time taken is shorter.

However, when considering the vertical direction, the vertical speed when travelling from P to Q is higher than the vertical speed when travelling from Q to R. Since the vertical distance is the same from P to Q and from Q to R, with larger speed when traveling from P to Q, the time taken for the object to travel from P to Q is lower than the time taken from Q to R.

show an understanding of the concept of work in terms of the product of a force and displacement in the direction of the force. L3

An object of weight *W* hangs from a trolley that runs along a rail. The trolley moves horizontally through a distance *p* and simultaneously raises the object through a height *q*.



As a result, the object moves through a distance *r* from X to Y. It starts and finishes at rest.

Which of the following statements about the object during this process **must** be correct?

A The work done on the object is *Wr*.

B The net work done on the object is 0.

C The gravitational potential energy at Y is Wq.

D The increase in kinetic energy of the weight is $W(p + q)$.

Answer: B

By the work-energy theorem the net work done is equals to the change in the kinetic energy of the object.

Since the object starts and ends at rest the change in kinetic energy is zero.

show an appreciation for the implications of energy losses in practical devices and use the concept of efficiency to solve problems. L2

) The data below are taken from a test of a petrol engine for a motor car.

power output	150 kW
fuel consumption	20 litres per hour
energy content of fuel	40 MJ per litre

Which expression will evaluate the efficiency of the engine?

A $\dfrac{150 \times 10^3}{40 \times 10^6 \times 20 \times 60 \times 60}$

B $\dfrac{150 \times 10^3 \times 60 \times 60}{20 \times 40 \times 10^6}$

C $\dfrac{150 \times 10^3 \times 40 \times 10^6 \times 20}{60 \times 60}$

D $\dfrac{150 \times 10^3 \times 20}{40 \times 10^3 \times 60 \times 60}$

Answer: B

$$\text{Efficiency} = \frac{P_{output}}{P_{input}} = \frac{150 \times 10^3 \text{ J s}^{-1}}{20 \text{ litres per hour} \times 40 \times 10^6 \text{ J per litre}} = \frac{150 \times 10^3 \times 60 \times 60}{20 \times 40 \times 10^6}$$

Two toy cars are set to run round a circular track of radius 80 m. Each of them moves at a constant speed. At time *t*, car A overtakes car B. 4 minutes later, car A passes B again for the second time.

What is the period of car A, if the period of car B was 60 seconds?

understand and use the concept of angular velocity to solve problems. L3

A 15 s **B** 48 s **C** 120 s **D** 240 s

Answer: B

When car A overtakes car B again, it must have travelled an additional lap as compared to the number of laps car B has travelled in the next 4 minutes.

Therefore,

$$\theta_A - \theta_B = 2\pi$$

$$\frac{2\pi}{T_A}(240) - \frac{2\pi}{(60)}(240) = 2\pi$$

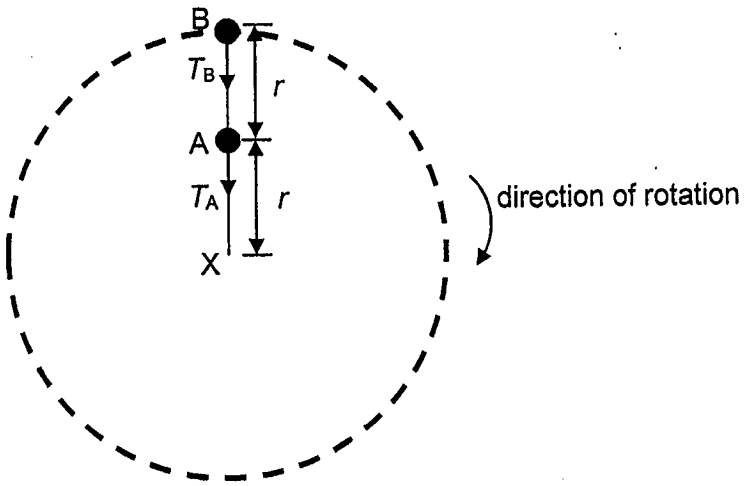
$$\frac{240}{T_A} - 4 = 1$$

$$T_A = \frac{240}{5}$$

$$= 48 \text{ s}$$

recall and use centripetal force $F = mr\omega^2$, $F = mv^2/r$ to solve problems. L3

Two spheres A and B of equal mass, m, are attached on a string which moves in a vertical circular motion. A is at a distance r while B is $2r$ away from the end of the string X as shown in the figure below.



The tensions in each part of the strings are T_A and T_B respectively.

Which of the following statements about the forces acting on objects A and B are correct?

A The magnitude of T_A and T_B are always constant.

B Throughout the motion, the net force acting on sphere A is only T_A.

C For the objects to execute circular motion T_B can have a magnitude of zero.

D The magnitude of T_A and T_B are always equal as they are action reaction forces.

Answer: C

Option A: Since it is a vertical circular motion, the magnitude of the tension T_A and T_B cannot be constant throughout.

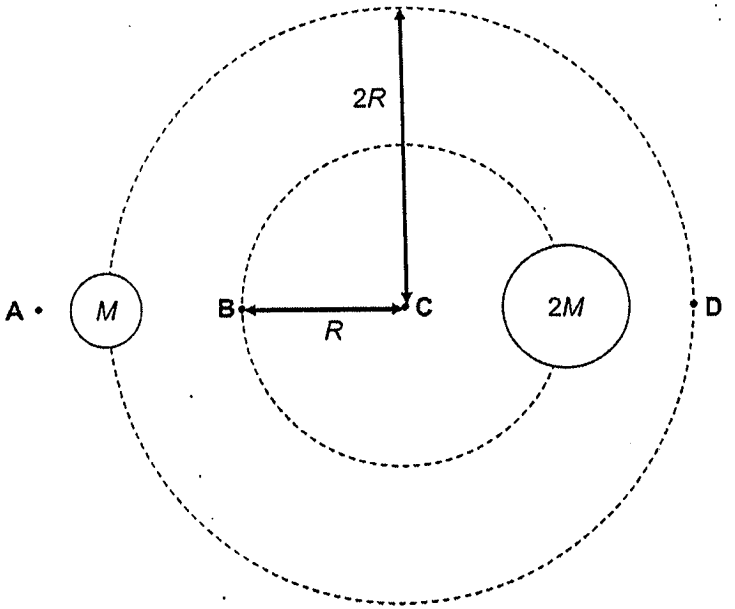
Option B: Sphere A will experience three forces acting on it all the time. T_A, T_B and its own weight mg.

Option C: This is true only when sphere B is at its maximum height with the minimum speed passing through that point such that its own weight is the only force necessary to contribute to the centripetal force.

Option D: T_A and T_B are not action reaction pair forces as these two forces exists on different segment of the strings. And their magnitudes can be only equal when the centripetal force acting on A is its own weight.

Two binary stars of masses M and $2M$ revolve about their common centre of mass in orbits of radius $2R$ and R respectively.

recall and apply the equation g = GM/r^2 for the gravitational field strength of a point mass to new situations or to solve related problems L2



At which point does the gravitational field strength have the lowest magnitude?

Answer: B

The point of the lowest magnitude of the field strength is at the neutral point, which should be between the two masses, where the forces due to the two stars can cancel out.

The neutral point is expected to be closer to the smaller mass, since the force due to two masses needs to be equal in magnitude and opposite in direction.

4 On October 19 2016, the spacecraft *Juno* will enter into a circular polar orbit with a period of 14 days around the planet Jupiter which has a mass of 1.90×10^{27} kg.

What is the radius of *Juno's* orbit?

A 8.64×10^{4} m **B** 1.67×10^{9} m **C** 6.29×10^{17} m **D** 4.69×10^{27} m

analyse circular orbits in inverse square law fields by relating the gravitational force to the centripetal accelerations it causes L2

Answer: B

Since the gravitational force of Jupiter provides for the centripetal force:

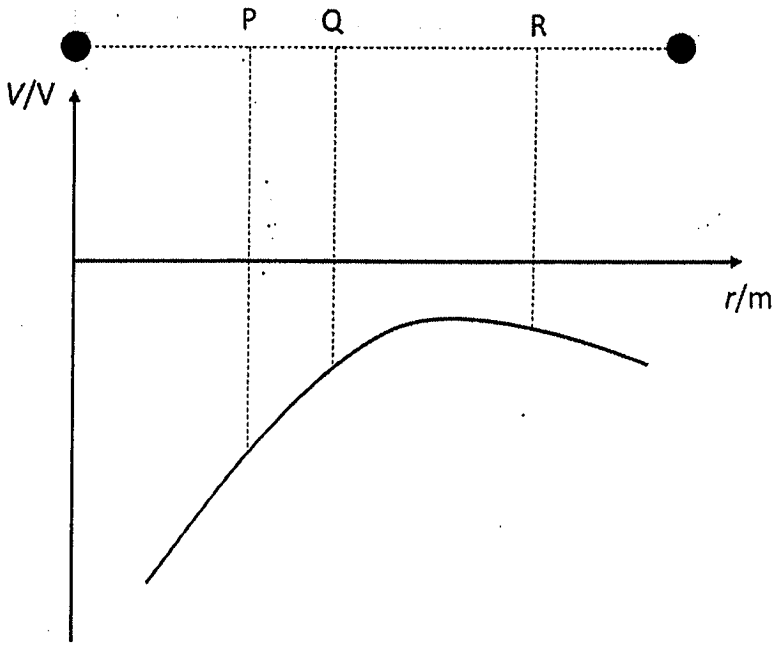
$$\frac{GMm}{r^2} = mr\omega^2$$

$$r^3 = \frac{GM}{\omega^2} = \frac{GMT^2}{4\pi^2}$$

$$r = \sqrt[3]{\frac{(6.67 \times 10^{-11})(1.90 \times 10^{27})(14 \times 24 \times 3600)^2}{4\pi^2}} = 1.67 \times 10^{9}\ \text{m}$$

5 Two charges are placed in free space. The variation of the electric potential V, with the distance r from the left charge along the line joining the centres of the charges is shown below.

define potential at a point in terms of the work done in bringing unit positive charge from infinity to the point. L3



Which of the following statements is true?

A Any charge placed at point P will experience a resultant force towards the left.

B The electric field strength at point Q is larger than the electric field strength at P.

C Net positive work needs to be done by an external agent to move a negative charge from point R to point P.

D A positive charge at P has more electric potential energy as compared to an identical positive charge placed at R.

Answer: C

Option A: Depending on the charge of the object, the force could either be left (positive charge) or right (negative charge).

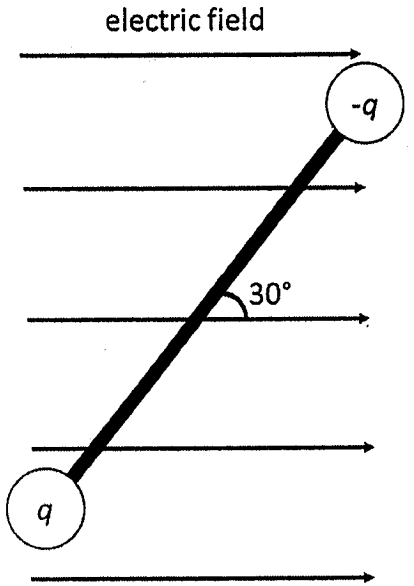
Option B: The magnitude of the field strength can be found using $E = -\frac{dV}{dr}$. The gradient at P is larger than Q, so the field strength is larger at P.

Option C: The potential at P is lower than R, and thus ΔV is a negative number. The work done is $W = q\Delta V$ and this is a positive number since q is also negative. So, the work done is positive.

Option D: The potential energy is given by $U = qV$, and so, since V is more negative at P than at R, the potential energy is lower at P than at R.

6 Two charges of electric charge q and $-q$ connected by a light electrically insulated rigid rod of length L are placed in a uniform electric field of electric field strength E as shown in the figure.

calculate the forces on charges in uniform electric fields. L2



Which of the following is the correct expression for the torque due to the couple?

A $\frac{qEL}{2}$

B qEL

C $2qEL$

D q^2E^2L

Answer: A

The torque due to a couple is found by:

τ = force of the couple × perpendicular distance between the couple

$= q \times E \times L \sin 30$

$= \dfrac{qEL}{2}$

An object moving in simple harmonic motion has a maximum velocity v_0 and an amplitude x_0.

What is its velocity, in terms of v_0, when it is at a distance $0.25x_0$ from its amplitude position?

recognise and use v = v0cosωt, v = ±√(x0^2 - x^2) L2

A $0.13v_0$

B $0.25v_0$

C $0.66v_0$

D $0.75v_0$

Answer: C

$v = \pm\omega\sqrt{x_0^2 - x^2}$

$= \pm\omega\sqrt{x_0^2 - (0.75x_0)^2}$

$= \pm\omega\sqrt{(1 - 0.75^2)x_0^2}$

$= \pm 0.66\omega x_0$

$= 0.66v_0$

Some doors use a spring system to ensure the door closes again after it is opened. These springs are usually damped.

describe the practical examples of damped oscillations with particular reference to L1

If the spring used causes critical damping in the door, which of the following will happen when the door is opened?

the effects of the degree of damping and the importance of critical damping in cases such as a car suspension system

A The door will quickly swing shut without oscillating.

B The door will continue to swing back and forth for a long time.

C The door will take a long time to swing shut without oscillating.

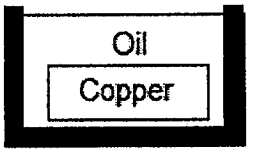
D The door will swing back and forth, but will come to a stop eventually.

Answer: A

Critical damping is defined as damped system where the object returns to equilibrium as quickly as possible. This matches the description in option A

9 A copper block at 500 °C is cooled in an oil bath that was initially at 20 °C.

Heat capacity **L2**



Using the ratios below, calculate the temperature at thermal equilibrium. Assume no heat transfer with the surroundings and the container.

$$\frac{\text{density of oil}}{\text{density of copper}} = 0.110$$

$$\frac{\text{specific heat capacity of oil}}{\text{specific heat capacity of copper}} = 4.29$$

$$\frac{\text{volume of oil bath}}{\text{volume of copper}} = 10.0$$

A 41.6 °C **B** 104 °C **C** 160 °C **D** 416 °C

Answer: B

Heat gain by oil = heat loss by copper

$m_o c_o \Delta T_o = m_c c_c \Delta T_c$

$V_o \rho_o c_o (T - 20) = V_c \rho_c c_c (500 - T)$

$$\frac{V_o\ \rho_o\ c_o}{V_c\ \rho_c\ c_c} = \frac{(500 - T)}{(T - 20)}$$

$$10 \times 0.110 \times 4.29 = \frac{(500 - T)}{(T - 20)}$$

$T = 104\ ^\circ C$

The temperature of an ideal gas is raised from 32.1 °C to 40.5 °C. What is the percentage increase in the r.m.s. speed of its gas particles? **Kinetic theory** **L2**

A 1.4% **B** 2.8% **C** 12% **D** 13%

Answer: A

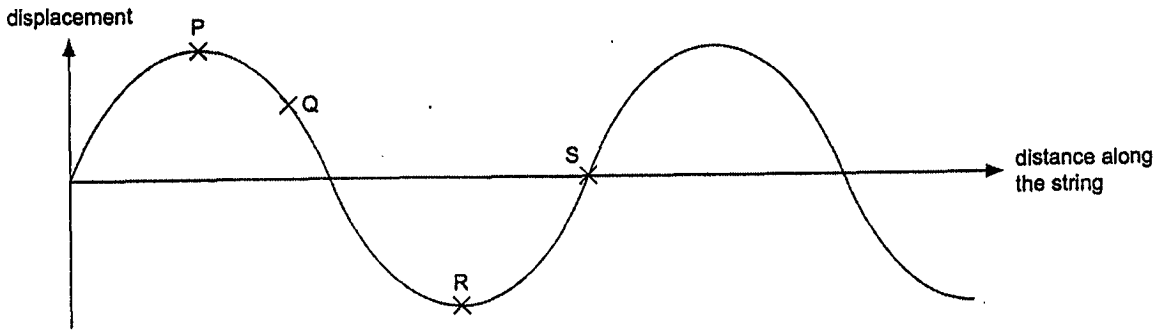
$C_{rms} \propto \sqrt{T}$

$$\frac{C_{rms,2}}{C_{rms,1}} = \sqrt{\frac{40.5 + 273.15}{32.1 + 273.15}}$$

$C_{rms,2} = 1.014 C_{rms,1}$

C_{rms} has increased by 1.4%

The figure shows the shape at a particular instant of part of a transverse wave travelling from left to right along a string. **Graphing disp - dist** **L2**



Which statement about the motion of elements of the string at this instant is correct?

A The speed of Q is higher than S.

B Both Q and S are moving upwards.

C The energy of P and S is entirely kinetic.

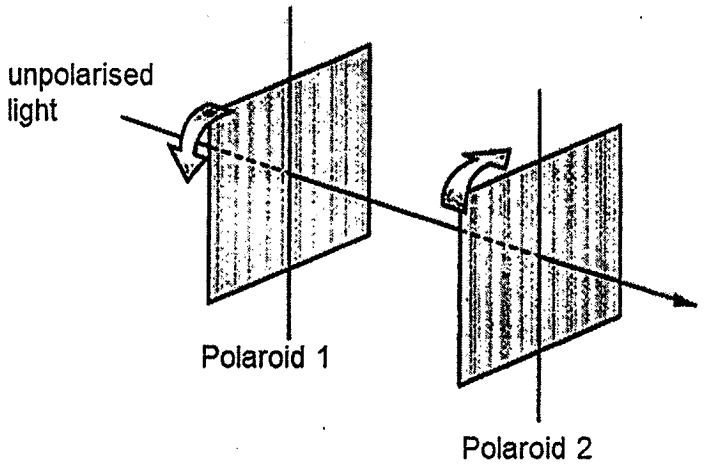
D The acceleration of P and R is a maximum.

Answer: D

Option A is incorrect S should be of higher speed since it is at the equilibrium position.
Option B is incorrect because both should be moving in opposite directions.
Option C is incorrect because kinetic energy of P (being at the amplitude) is 0.
Option D is the answer because acceleration is proportional to displacement from the equilibrium position.

2 The diagram shows a beam of initially unpolarised light passing through two Polaroid filters.

polarisation **L2**



The transmitting axes of these filters are initially aligned. The two filters are now rotated through 360° in opposite directions in their own plane at equal speeds.

How many maxima of intensity occur in the light emerging from the Polaroid on the right?

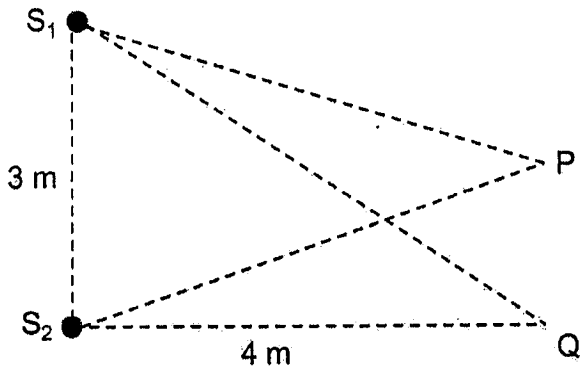
A 2 **B** 3 **C** 5 **D** 9

Answer: C

Maxima will be obtained when the filters are aligned parallel to each other.
In a rotation of 360°, that occurs a total of 5 times (including at the start).

Two source interference **L1**

Two sources of waves, S_1 and S_2, are situated as shown in the figure below. Individually, each source emits waves of intensity I.



Equidistant from S_1 and S_2, a detector at P registers a steady minimum wave intensity. The same detector registers the next steady minimum intensity when it moves to point Q. Which of the following statements is false about the two sources of waves?

A The two sources of waves are coherent.

B The two sources of waves have the same amplitude.

C The two sources of waves have a similar wavelength of 2 m.

D The two sources of waves have a phase difference of π radians.

Answer: C

To obtain a steady interference with minimum intensity at point P, both the sources must be coherent and be out of phase by π radians. Both sources can be of the same amplitude. The next minimum produced at Q corresponds to a path difference of 1 m and this should be equal to one wavelength. Thus, the wavelength of the waves must be 1 m and not 2 m.

Diffraction grating **L2**

Monochromatic light is incident normally on a diffraction grating and first order diffraction is observed at an angle of 28.6°.

Which of the following statements about the diffraction pattern produced by the grating is true?

A The second order image is observed at 57.2° and there is a total of 3 intensity maxima formed on the screen.

B The second order image is observed at 57.2° and there is a total of 5 intensity maxima formed on the screen.

C The second order image is observed at 73.2° and there is a total of 5 intensity maxima formed on the screen.

D The second order image is observed at 73.2° and there is a total of 7 intensity maxima formed on the screen.

Answer: C

Using $d\sin\theta = n\lambda$

$\frac{d}{\lambda} = \frac{n}{\sin\theta} = \frac{1}{\sin 28.6}$

For 2nd order image,

$\frac{d}{\lambda} = \frac{1}{\sin 28.6} = \frac{2}{\sin\theta_2}$

$\theta_2 = 73.2°$

Highest order max visible is determined from largest angle of diffraction possible where $\theta = 90°$

$\frac{d}{\lambda} = \frac{1}{\sin 28.6} = \frac{n}{\sin 90}$

$n = 2.089 = 2$ (2 max on each side of the central max, total max = 2+2+1 = 5)

The potential difference across an electrical component is 20 V. The time taken for charge carriers to move through this component is 15 s, and, in this time, the energy of the charge carriers changes by 12 J.

What is the electrical resistance of this component?

A 0.040 Ω **B** 0.80 Ω **C** 33 Ω **D** 500 Ω

recall and using problems W/Q. solve V = L2

Answer: D

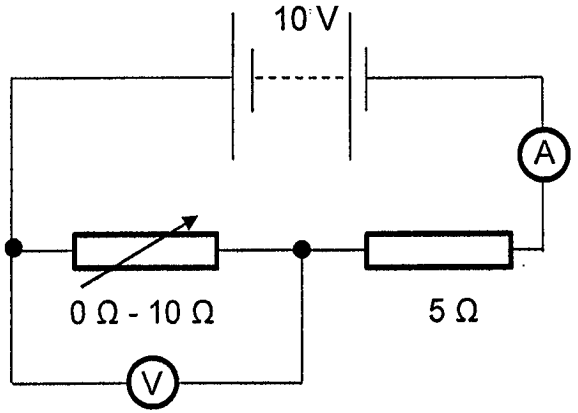
Charge flowing through component = $\frac{W}{V} = \frac{12}{20} = 0.600$ C

Current flowing through = $\frac{Q}{t} = \frac{0.600}{15} = 0.04$ A

Resistance of the component = $\frac{V}{I} = \frac{20}{0.04} = 500\ \Omega$

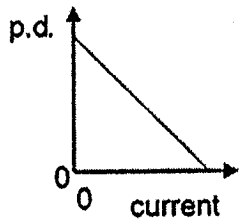
6 A 10 V battery is in series with an ammeter, a 5 Ω fixed resistor and a 0 - 10 Ω variable resistor. A high-resistance voltmeter is connected across the variable resistor.

show an understanding of the use of a potential divider circuit as a source of variable p.d. L3

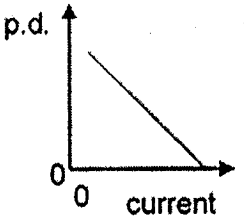


The resistance of the variable resistor is changed from zero to its maximum value.

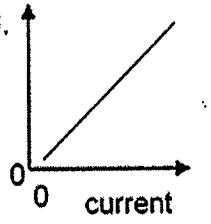
Which graph shows how the potential difference (p.d.) measured by the voltmeter varies with the current measured by the ammeter?



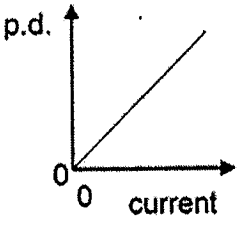
A



B



C



D

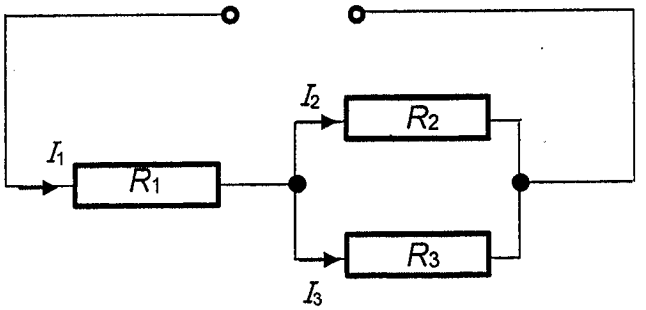
Answer: B

When the resistance of the variable resistor is set to its minimum (0 Ω) the p.d. is zero. But that is when the current in the entire circuit is its maximum.

On the other hand when the resistance of the variable resistor is at its maximum (10 Ω) the p.d is non-zero while the current is a non-zero minimum and therefore, the graph should not touch the y-axis.

The circuit diagram shows three fixed resistors R_1, R_2 and R_3 connected to a power supply. The currents flowing through each of these resistors are I_1, I_2 and I_3 respectively.

solve problems involving series and parallel circuits for one source of e.m.f. L2



Which of the following expression represents the ratio of $\frac{R_2}{R_3}$?

A $\frac{I_2}{I_3}$

B $\frac{I_1}{I_3} - 1$

C $\frac{I_1}{I_2} - 1$

D $1 + \frac{I_3}{I_2}$

Answer: C

Since R_2 and R_3 are in parallel, the potential difference is equal across both of them.

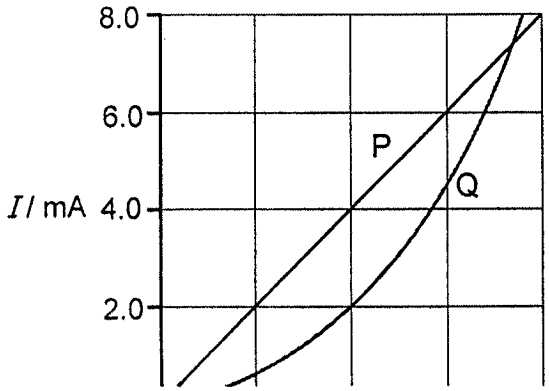
So, $I_2R_2 = I_3R_3$

$$\frac{R_2}{R_3} = \frac{I_3}{I_2}$$

$$= \frac{I_1 - I_2}{I_2}$$

$$= \frac{I_1}{I_2} - 1$$

3 The *I*-V characteristics of two electrical components P and Q are shown below.



sketch and explain the I-V characteristics of a metallic conductor at constant temperature, a semiconductor diode and a filament lamp. L3

Which statement is correct?

A P is a resistor and Q is a filament lamp.

B The ratio $\frac{\text{resistance of P}}{\text{resistance of Q}}$ is always less than 1.

C At 2.0 mA the power dissipated through Q is always twice that of P.

D At the point where the two lines intersect the resistance of Q is approximately twice that of P.

Answer: D

Option A: P is an ohmic conductor (resistor) while Q is a semiconductor.

Option B: Resistance of P is always smaller than the resistance of Q for values of V to the left of the intersection point. At the intersection point the resistance are equal. While to the right the resistance of P is larger than the resistance of Q.

Option C: The power dissipated in the resistors at 2.0 mA is proportional to $\frac{V^2}{R}$ or (I^2R)

$$\text{So } \frac{\text{Power dissipated through P}}{\text{Power dissipated through Q}} = \frac{V_P^2}{R_P} \div \frac{V_Q^2}{R_Q}$$

$$= \frac{V_P^2}{V_Q^2} \times \frac{R_Q}{R_P}$$

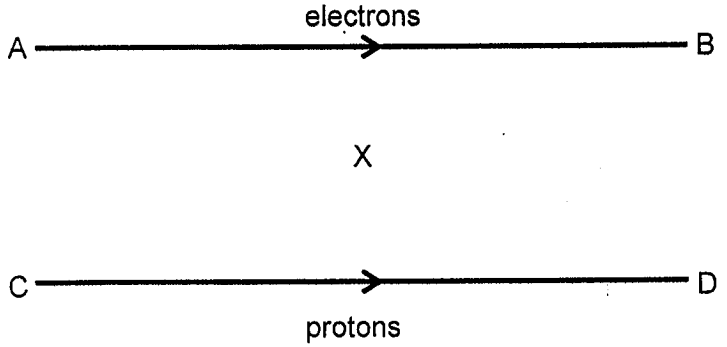
$$= \left(\frac{4}{8}\right)^2 \times \frac{\frac{8}{2\times10^{-3}}}{\frac{4}{2\times10^{-3}}}$$

$$= \frac{1}{2}$$

∴ Power dissipated through Q is twice the power dissipated through P.

Option D At the point of intersection the resistance of P and Q are equal

9 A beam of electrons in AB and another made out of protons in CD are parallel to each other.



The rate of proton flow in CD is twice that of the electrons in AB. What direction is the magnetic field at point X, which is equidistant from AB and CD?

A Towards AB **B** Towards CD **C** Into the page **D** Out of the page

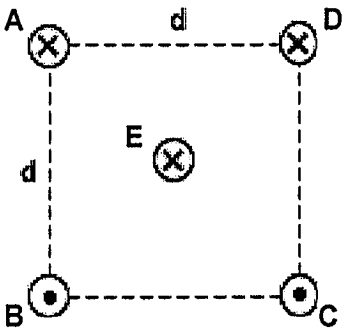
Answer: D

show an appreciation that a force might act on a current-carrying conductor placed in a magnetic field. L1

The current is flowing from B to A and C to D and using the Right Hand Grip Rule, the magnetic field at X is pointing outwards from the paper.

Five straight and parallel wires are arranged as shown in the diagram below, and each carries a steady current *I*.

show an appreciation that a force might act on a current-carrying conductor placed in a magnetic field. L2



Which of the following statements incorrectly describes the above scenario?

A The resultant force on wire E due to wires A, B, C and D is pointing towards line AD, perpendicular to AD.

B The resultant force on wire E due to wires B and C is pointing towards line AD, perpendicular to AD.

C The resultant force on wire E due to wires A and D is pointing towards line AD, perpendicular to AD.

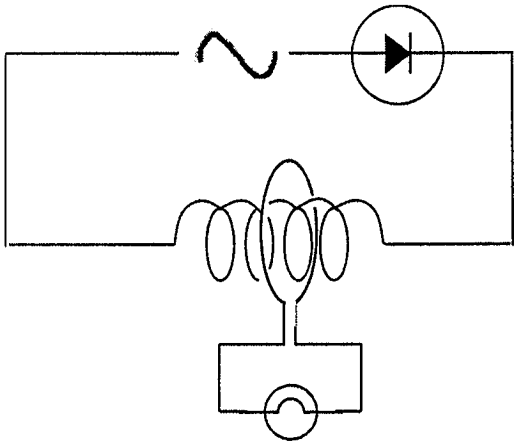
D The resultant force on wire E due to wires B and D is pointing towards line AD, perpendicular to AD.

Answer: D

Using FLHR, all scenarios from options A to C are correct, while option D is incorrect.

A circuit containing a circular loop of wire connected to a low power light bulb is positioned around a solenoid connected to a sinusoidal AC source and a diode as shown in the diagram below.

explain simple applications of electromagnetic induction. L2



Which of the following statements is true?

A The light bulb lights up because the magnetic flux linkage through the loop varies with time.

B The light bulb lights up because the magnetic flux linkage through the loop reverses its direction every cycle.

C The light bulb does not light up because the magnetic flux linkage through the loop does not reverse its direction.

D The light bulb does not light up because the diode prevents current from flowing and thus producing any magnetic flux in the solenoid.

Answer: A

With a variation of the current, there is a variation of magnetic flux density, and thus magnetic flux linkage. An e.m.f. will be induced in the secondary circuit causing the bulb to be lit.

2 Two coils are linked by a soft iron bar as shown in Fig. A. A current source is connected to the primary coil. The primary current *Ip* varies with time as shown by the Fig. B.

show an understanding of the principle of operation of a simple iron-cored transformer and recall and solve problems using Ns /Np = Vs /Vp = L2

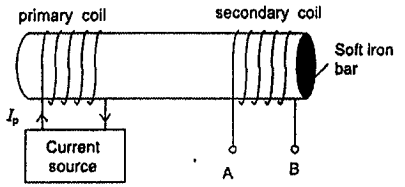


Fig. A

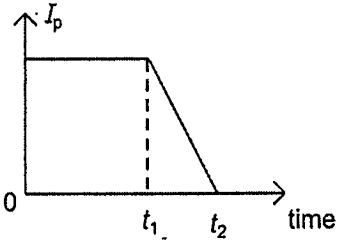
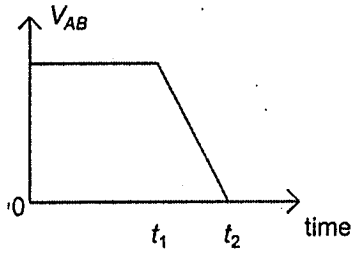


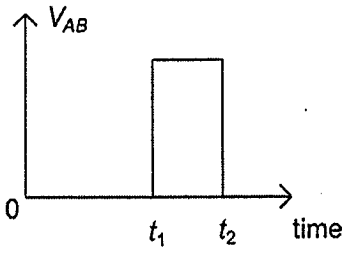
Fig. B

Which of the following sketches represents the variation of the voltage across the secondary coil V_{AB} with time?

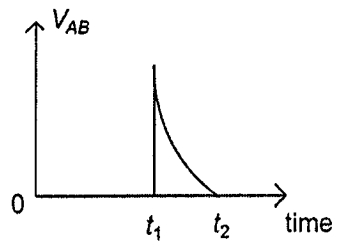
A



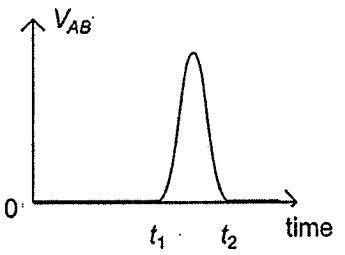
B



C



D



Answer: B

As the current in the primary coil changes, it will induce a current in the secondary coil due to the changing magnetic flux linkages in the secondary coil, according to Faraday's Law.

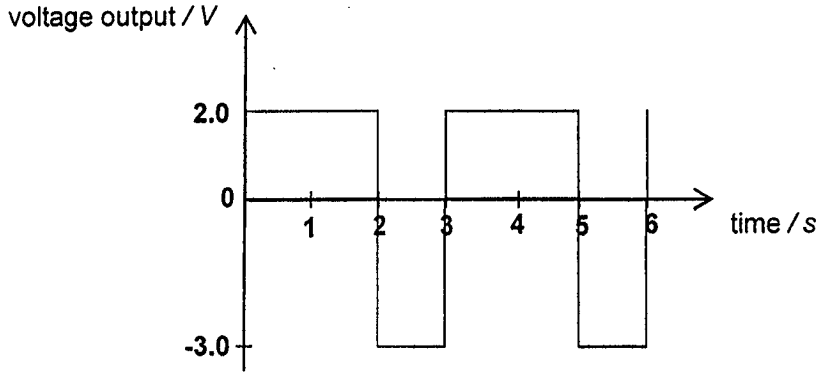
$$E = -\frac{d\Phi}{dt}$$

Ip /Is for an ideal transformer.

Since the current in the primary coil changes linearly from t_1 to t_2, so will the magnetic flux linkage in the primary (and secondary coil, as linked by the soft iron core). Therefore, according to the relationship above, the induced emf in the secondary coil will be a constant non-zero value during time period t_1 to t_2.

3 A 20 Ω resistor is connected to an AC power supply with a voltage output that varies from 2.0 V to – 3.0 V as shown on the graph below.

show an understanding and use the terms period, frequency, peak value and root-mean-square value as applied to an alternating current or voltage. L2



What is the average heating power dissipated in the resistor?

A 0.083 W **B** 0.28 W **C** 0.43 W **D** 0.65 W

Answer: B

$$\text{Average power} = \frac{V_{rms}^2}{R} = \frac{1}{20}\left(\frac{2^2 \times 2 + 3^2 \times 1}{3}\right) = 0.28\ \text{W}$$

4 Which of the following statements about the wave-particle duality is true?

describe and interpret qualitatively the evidence provided by L2

electron diffraction for the wave nature of particles.

A The wave-particle duality suggests that every particle will have an associated wavelength when it moves, provided that it is subatomic in size.

B The wave-particle duality suggests that every particle will have an associated wavelength when it moves, regardless of whether it has a mass or not.

C The wave-particle duality suggests that every particle will have an associated wavelength when it moves, provided that they have a non-zero charge.

D The wave-particle duality suggests that every particle will have an associated wavelength when it moves, provided that it is undergoing quantum tunneling.

Answer: B

This principle is applied for all particles, regardless of mass, charge and size.

The fastest recorded tennis serve was measured to have a speed of (73.2 ± 0.1) m s^{-1} and an average tennis ball has a mass of 58.0 g.

What is the minimum uncertainty of its position?

show an understanding of and apply the Heisenberg position-momentum and time-energy uncertainty principles in new situations or to solve related problems. L2

A 9.09×10^{-33} m **B** 1.24×10^{-35} m **C** 9.09×10^{-36} m **D** 1.24×10^{-38} m

Answer: A

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

$$\Delta x \geq \frac{h}{4\pi(\Delta p)}$$

$$\Delta x \geq \frac{h}{4\pi m(\Delta v)}$$

$$\Delta x \geq \frac{6.63\times10^{-34}}{4\pi(0.058)(0.1)}$$

$$\Delta x \geq 9.09\times10^{-33}\, m$$

6 Which of the following changes will increase the probability of a particle tunneling through a potential barrier?

apply the relationship transmission coefficient T ú exp(– 2kd) for the STM in related situations or to solve problems. (Recall of the equation is not required.) L2

A Increasing the width of the potential barrier

B Increasing the height of the potential barrier

C Shooting particles of a smaller mass at the potential barrier

D Decreasing the energy of the particles incident on the potential barrier

Answer: C

Looking at formula for the transmission coefficient, it can be seen that increasing the potential barrier height and width and decreasing the energy of the particles will decrease the probability of transmission. Only decreasing the mass will increase the probability.

Which of the following best describes the meaning of population inversion?

recall and use the terms spontaneous emission, stimulated emission and population inversion in related situations. L1

A Electrons are able to stay in such a state for a longer period.

B An atom in an excited state undergoes a transition to the ground state and emits a photon.

C The number of atoms at a lower energy state exceeds the number of atoms at a higher energy state.

D The number of atoms at a higher energy state exceeds the number of atoms at a lower energy state.

Answer: D

Option A is referring to a metastable state.
Option B is referring to the spontaneous emission of an electron
Option C is the atom in its natural state

Which of the following statements about a semiconductor diode in forward bias is incorrect?

discuss qualitatively the origin of the depletion region at a p-n junction and use this to explain how a p-n junction can act as a rectifier. L2

A Holes will move away from the p-n junction due to the external electric field.

B Electrons in the n-type semiconductor will cross steadily to the p-type semiconductor.

C The applied potential difference from the external source of e.m.f. opposes the junction potential.

D The n-type material of the diode is connected to the negative terminal of the external source of e.m.f.

Answer: A

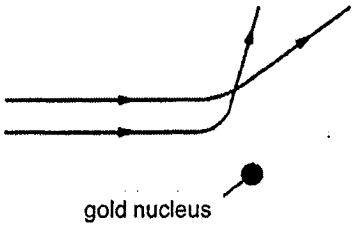
Holes will only move away from the diode in the reverse bias configuration. The remaining options describe the conditions and the mechanism of a forward bias flow. The n-type semiconductor will be connected to the negative terminal of the e.m.f. source, and this will lead to the mobile electrons experiencing an electric force that will allow them to move across the p-n junction.

9 Two alpha particles with equal energies are fired towards the nucleus of a gold atom.

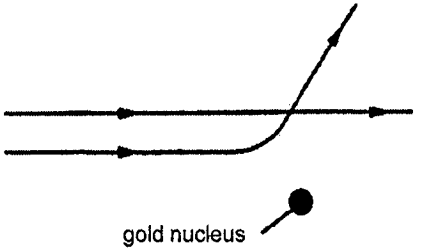
Which diagram could represent their path?

infer from the results of the α-particle scattering experiment the existence and small size of the nucleus. L1

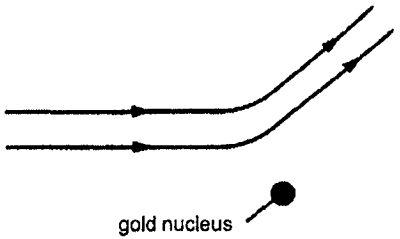
A



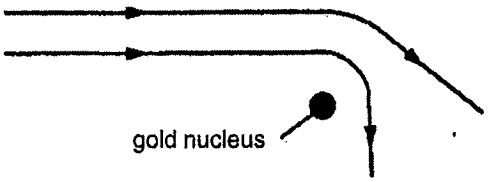
B



C



D



Answer: A

Due to the electric force of repulsion that decreases in magnitude as the distance between charged particles of the same charge increases, the angle of deflection will be lesser.

0 A newly prepared radioactive nuclide has a decay constant of 10^{-6} s^{-1}.

What is the approximate half-life of the nuclide?

solve problems using the relation $\lambda = 0.693/t_{1/2}$ L1

A 1 hour

B 1 day

C 1 week

D 1 month

Answer: C

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

$$t_{1/2} = \frac{\ln 2}{\lambda}$$

$$= \frac{\ln 2}{\lambda}$$

$$= \frac{\ln 2}{10^{-6}} = 6{,}93 \times 10^{6} \approx 8\ days$$