JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME			
CLASS		INDEX NUMBER	

PHYSICS **9646/01**

Paper 1 Multiple Choice **30 August 2016**

Additional Materials: Multiple Choice Answer Sheet **1 hour 15 minutes**

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, civics group and index number on the Answer Sheet in the spaces provided unless this has been done for you.

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 separate Answer Sheet.

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.

Innova Junior College

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	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm\, \omega\sqrt{(x_o^2 - x^2)}$
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,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
transmission coefficient	T	$\propto$	$\exp(-2kd)$
	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 In an experiment to determine the acceleration of free fall g, a ball bearing is held by an electromagnet. When the current to the electromagnet is switched off, a clock starts and the ball bearing falls. After falling a distance h, the ball bearing strikes a switch to stop the clock which measures the time of the fall, t.

The readings for h and t obtained by a student are as follow

$$h = (0.785 \pm 0.002)\ \text{m}$$
$$t = (0.4000 \pm 0.0008)\ \text{s}$$

Which row correctly states the fractional uncertainty of g and the physical quantity that affects the fractional uncertainty of g most?

	fractional uncertainty of g	physical quantity that affects the fractional uncertainty of g most
A	6.55×10^{-3}	time of fall, t
B	6.55×10^{-3}	distance fallen, h
C	1.45×10^{-3}	time of fall, t
D	1.45×10^{-3}	distance fallen, h

2 A car is travelling at its cruising speed on an expressway. It is then brought to rest.

Which value is most likely to represent the car's change of momentum?

A 3×10^{3} kg m s^{-1}
B 3×10^{4} kg m s^{-1}
C 3×10^{5} kg m s^{-1}
D 3×10^{6} kg m s^{-1}

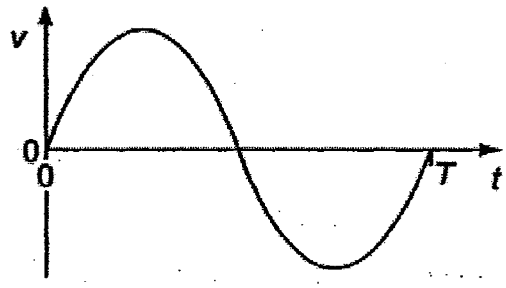
3 On a particular railway, a train driver applies the brakes of the train when passing a yellow signal which is at a distance of 1.00 km from a red signal where the train must stop.

The maximum deceleration which the train bogie can withstand is 0.215 m s^{-2}. The train can be assumed to decelerate uniformly.

Of the following options, which gives the maximum speed that the train can pass the yellow signal, and still stop safely at the red signal?

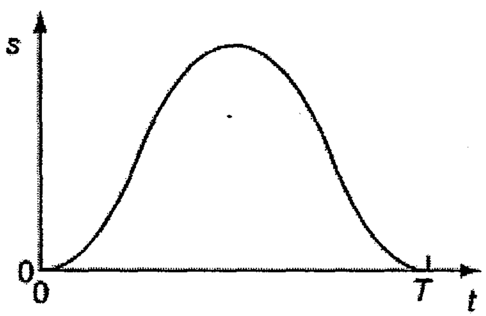
A 19.0 m s^{-1} **B** 20.0 m s^{-1} **C** 21.0 m s^{-1} **D** 440 m s^{-1}

4 The graph shows the variation of the velocity v of an object moving in a straight line with time t.

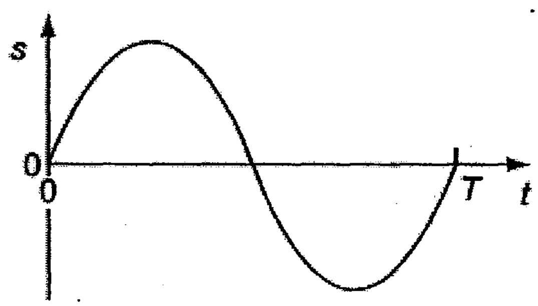


Which graph represents the displacement s of the object from $t = 0$ to $t = T$?

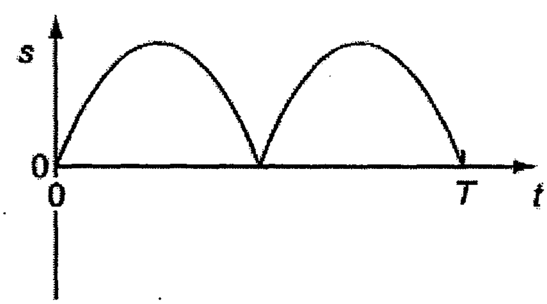
A



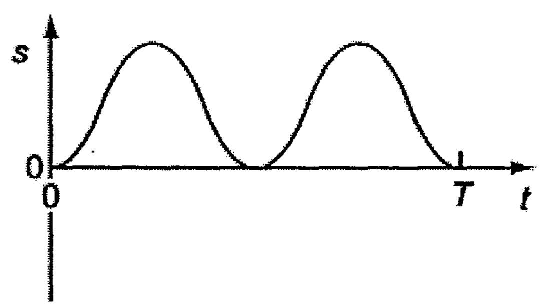
B



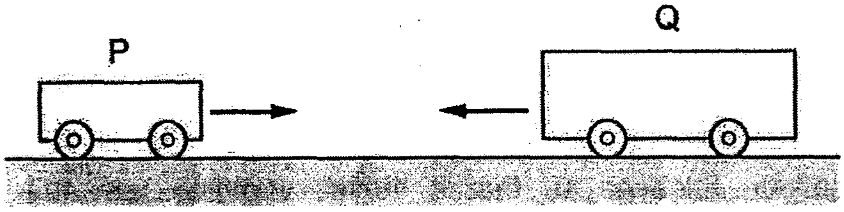
C



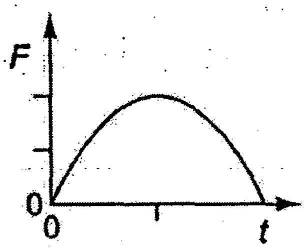
D



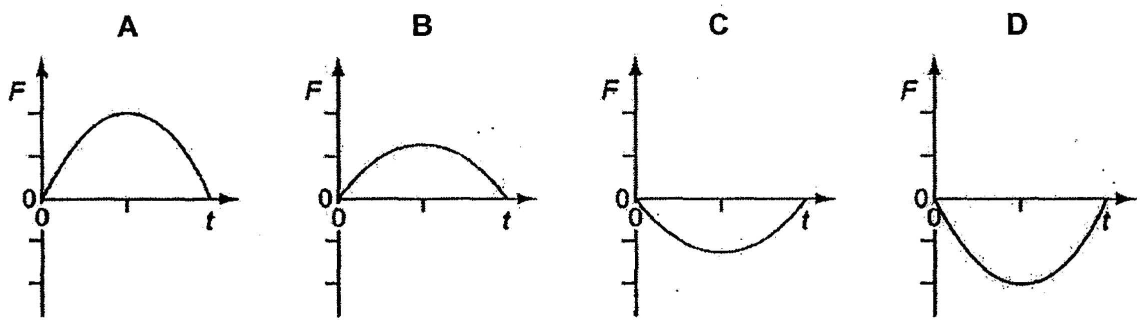
5 Two trolleys P and Q approach each other and collide.



The graph shows the variation with time t of the force F of P on Q.



Which graph, drawn to the same scale, shows the variation with time t of the force F of Q on P?



6 A horizontal jet of water strikes a vertical wall and flows down the wall without splashing.

Which quantity equals the magnitude of the force exerted by the jet on the wall?

A change in kinetic energy of the water per length of jet stopped

B change in momentum of the water stopped per second

C rate of loss of kinetic energy of the water

D weight of the water stopped per second

7 A cylindrical block of wood has a cross-sectional area A and weight W. It is totally immersed in water with its axis vertical. The block experiences pressures p_t and p_b at its top and bottom surfaces respectively.

Which of the following expressions is equal to the upthrust on the block?

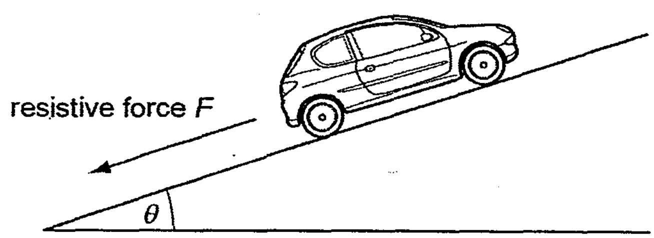
A $W-(p_b-p_t)A$

B $(p_b-p_t)A-W$

C $(p_b-p_t)A$

D (p_b-p_t)

8 A car of mass m travels at constant speed up a slope at an angle θ to the horizontal, as shown in the diagram. Air resistance and friction provide a resistive force F.



What is the driving force provided by the car's engine?

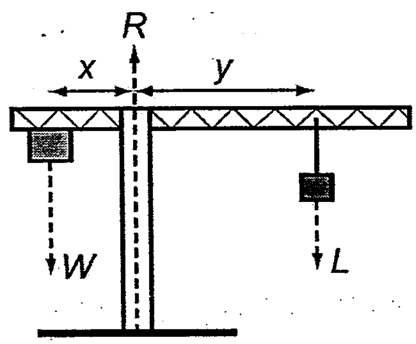
A $mg\cos\theta$

B $mg\sin\theta$

C $mg\cos\theta + F$

D $mg\sin\theta + F$

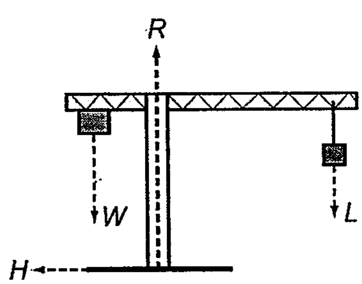
9 The diagram shows a crane supporting a load *L*.



A mass provides a balancing load *W*. The position of the loads are such that the system is perfectly balanced with $Wx = Ly$. The ground provides a reaction force *R*.

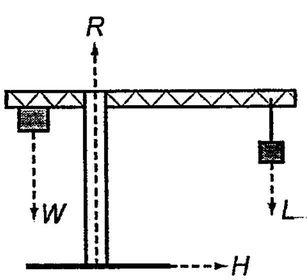
If the load *L* is moved further out so that the distance *y* increases, and the crane does not topple, which statement is correct?

A



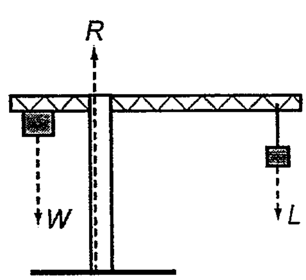
A horizontal force *H* acts on the base of the support column towards the left.

B



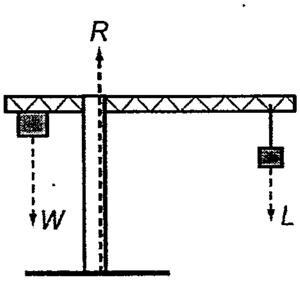
A horizontal force *H* acts on the base of the support column towards the right.

C



The reaction force *R* moves to the left.

D



The reaction force *R* moves to the right.

10 A crate is pushed 10 m along a horizontal surface by a force of 80 N. The frictional force opposing the motion is 60 N.

How much of the work done is converted into thermal energy and how much into kinetic energy of the crate?

	thermal energy / J	kinetic energy / J
A	200	600
B	200	800
C	600	200
D	600	800

11 The force resisting the motion of a car is proportional to the square of the car's speed. The magnitude of the force at a speed of 20 m s^{-1} is 800 N.

What effective power is required from the car's engine to maintain a steady speed of 40 m s^{-1}?

A 3.2 kW **B** 64 kW **C** 128 kW **D** 512 kW

12 A pendulum bob of mass 1.27 kg, and supported by a string 0.600 m long, is travelling in a vertical circle.

The linear velocity of the bob at the bottom of the circle is 5.75 m s^{-1}.

What is the tension in the string when the bob is at the top of the circle?

A 7.69 N **B** 20.1N **C** 70.0 N **D** 82.4 N

13 Which statement about a geostationary satellite is true?

A It can remain vertically above any chosen point on the Earth's surface.
B It can orbit at any height above the Earth's surface.
C It has the same angular velocity as the Earth's rotation on its axis.
D It has the same linear velocity as a person on the Earth's surface.

14 A satellite orbits a planet at a distance *r* from its centre. Its gravitational potential energy is – 3.2 MJ.

Another identical satellite orbits the planet at a distance 2*r* from its centre.

What is the sum of the kinetic energy and the gravitational potential energy of this second satellite?

A – 0.40 MJ **B** – 0.80 MJ **C** – 1.6 MJ **D** – 6.4 MJ

15 The tip of each prong of a tuning fork emitting a note of 319 Hz vibrates in simple harmonic motion with an amplitude of 0.50 mm.

What is the speed of each tip when its displacement is zero?

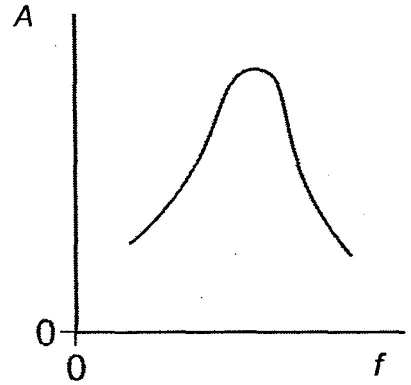
A Zero

B 1.0 mm s^{-1}

C 500 mm s^{-1}

D 1000 mm s^{-1}

16 A periodic force is applied to a lightly-damped object causing the object to oscillate. The graph shows how the amplitude A of the oscillations varies with the frequency f of the periodic force.



Which of the following statements best describe how the shape of the curve would differ if the damping had been greater?

A The curve would be lower at all frequencies.

B The curve would be higher at all frequencies.

C The curve would be unchanged except at frequencies above the resonant frequency where it would be lower.

D The curve would be unchanged except at frequencies above the resonant frequency where it would be higher.

17 In a heating experiment, energy is supplied at a constant rate to a liquid, contained in a beaker of negligible heat capacity.

The temperature of the liquid rose at 4.0 K per minute before it began to boil. It took 40 minutes from the instant the liquid started to boil, for all the liquid to boil away.

For this liquid, what is the ratio of $\frac{\text{specific latent heat of vaporisation}}{\text{specific heat capacity}}$?

A 10 K **B** 40 K **C** 160 K **D** 640 K

18 The pressure p of a gas occupying a volume V and containing N molecules of mass m each and mean square speed $<c^2>$, is given by

$$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$$

The density of argon at a pressure of 1.00×10^5 Pa and temperature 300 K, is 1.60 kg m^{-3}.

What is the root mean square speed of argon molecules at this temperature?

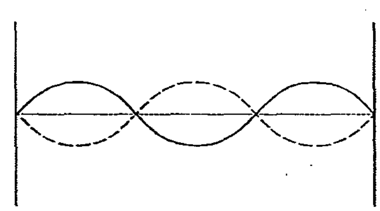
A 216 m s^{-1} **B** 250 m s^{-1} **C** 306 m s^{-1} **D** 433 m s^{-1}

19 The distance between two points of a progressive transverse wave having a phase difference of $\frac{\pi}{3}$ rad is 40 cm.

If the frequency of the wave is 200 Hz, what is the speed of the wave?

A 240 m s^{-1} **B** 480 m s^{-1} **C** 24 000 m s^{-1} **D** 48 000 m s^{-1}

20 A stretched string fixed at two ends is plucked in the centre and vibrates between two extreme positions as shown by the bold and dashed curves in the figure below. The horizontal dashed line is the equilibrium position.



Which one of the following statements is **false**?

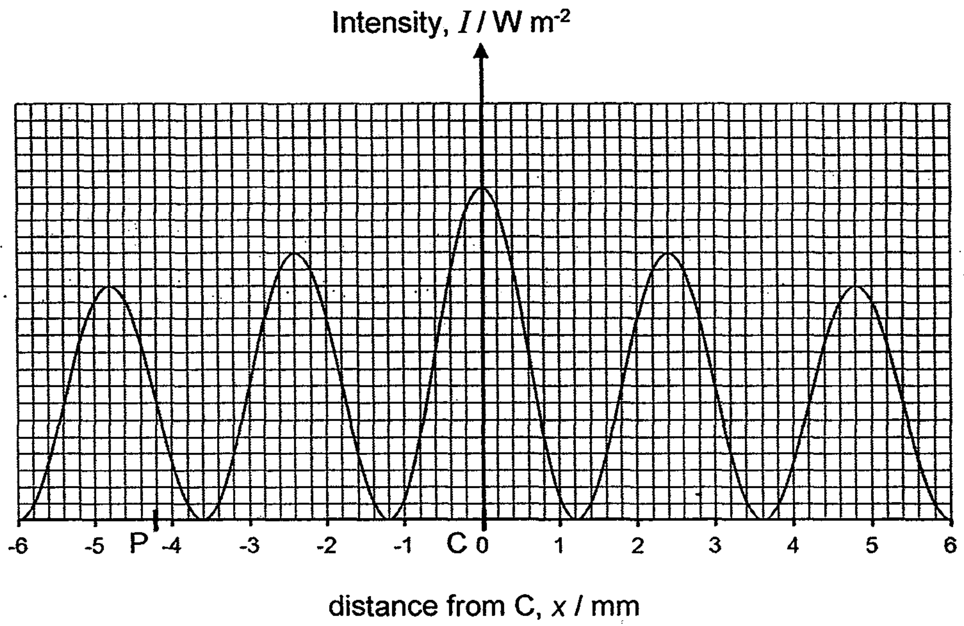
A The sound generated by the vibration is a standing longitudinal wave.

B There are four displacement nodes and three displacement antinodes.

C A transverse stationary wave is formed in the string.

D This mode of vibration is the third lowest frequency.

21 In a Young's double slit experiment, coherent monochromatic light incidents normally on a double slit. The figure below shows the variation with distance from C of the intensity I of the light on the screen. C is the central bright fringe on the screen.



If P is a point on the screen and its position is indicated in the figure above, what is the phase angle between the two waves from the double slit, when the waves meet at P?

A $\frac{\pi}{2}$ rad **B** $\frac{3\pi}{4}$ rad **C** $\frac{5\pi}{4}$ rad **D** $\frac{3\pi}{2}$ rad

22 A diffraction grating has 625 lines per mm. A beam of light incidents normally on the grating. The first order maximum makes an angle of 20° with the undeviated beam.

What is the wavelength of the incident light?

A 550 nm **B** 420 nm **C** 270 nm **D** 210 nm

23 A negative ion is projected into an electric field.

Which one of the following statements is correct?

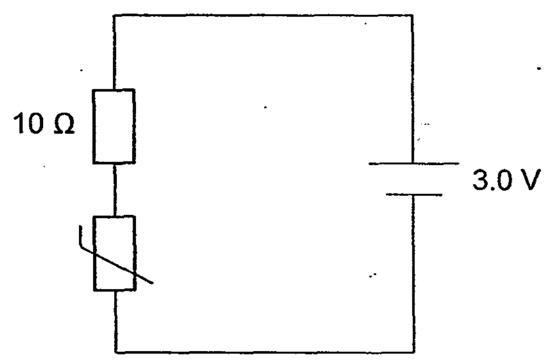
A The field can change the magnitude of the ion's velocity but not its direction.
B The field can change the direction of the ion's velocity but not its magnitude.
C The field can change both the magnitude and the direction of the ion's velocity.
D The ion will accelerate in the direction of the field.

24 Two parallel metal plates have a potential difference between them of 12 V. The distance between the plates is 1.0 mm.

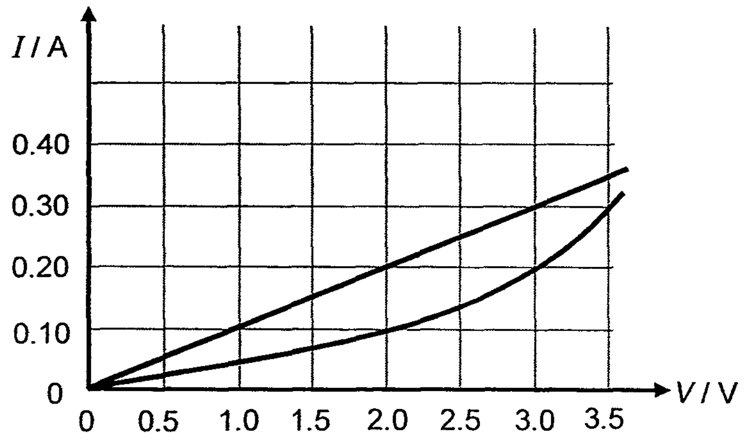
What is the electric field strength between the plates, and the work done in moving a charge of +3.9 μC from the negative plate to the positive plate?

	electric field strength / N C^{-1}	work done / J
A	12	4.7×10^{-5}
B	12	-4.7×10^{-5}
C	12 000	4.7×10^{-5}
D	12 000	-4.7×10^{-5}

25 A 10 Ω resistor and a thermistor are connected in series to a battery of e.m.f. 3.0 V and negligible internal resistance as shown in the figure below.



The graph below shows the current flowing through the thermistor and the resistor corresponding to the potential difference across them.

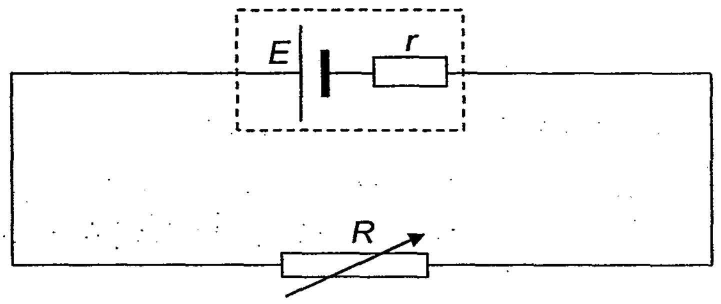


What is the current flowing through the battery in the circuit above?

A 0.10 A **B** 0.20 A **C** 0.30 A **D** 0.50 A

For questions 26 and 27, refer to the diagram below.

A battery of e.m.f E and internal resistance r is connected to a variable resistor R as shown below. When $R = 16\ \Omega$, the current in the circuit is 0.50 A. It is found that the battery supplies 4500 J of energy for a duration of 1.0×10^3 s.



26 What is the e.m.f. of the battery?

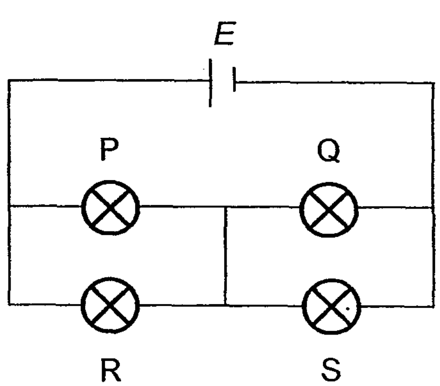
A 9.0 V **B** 10.0 V **C** 11.0 V **D** 12.0 V

27 What is the energy dissipated due to the internal resistance?

A 4.0 J **B** 4.5 J **C** 500 J **D** 4000 J

28 Four identical lamps are connected as shown below.

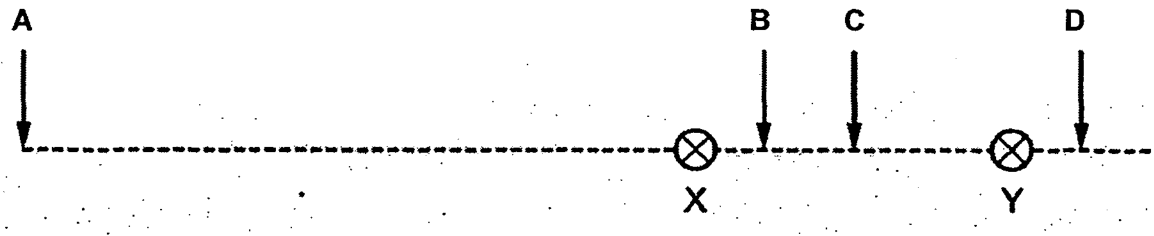
What happens when lamp P is blown out?



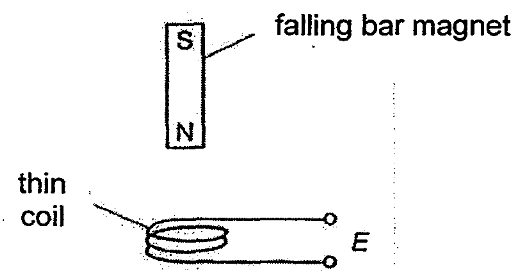
A Lamp R will not light up.
B Lamp Q and S will remain as bright as before.
C Lamp Q will become brighter than before.
D Lamp R will become brighter than before.

29 Two parallel wires X and Y carry equal currents vertically down into the paper.

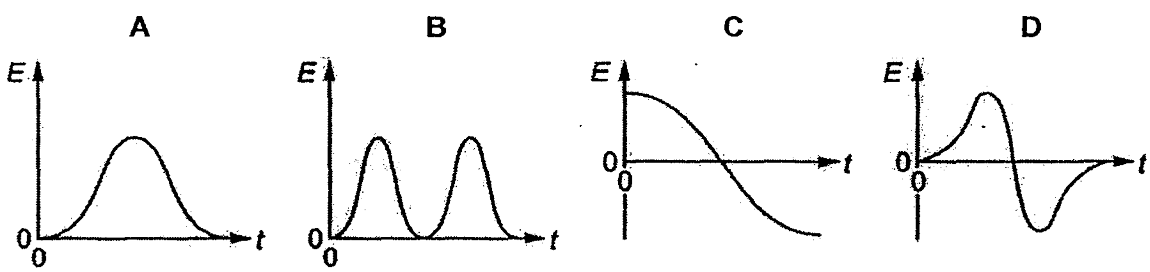
At which point must a third current-carrying wire be placed so that it experiences the minimum magnetic force due to the resultant magnetic field caused by the currents in X and Y?



30 In an experiment to record electrical events of short duration, a student drops a bar magnet through a very thin, horizontal coil, as shown.

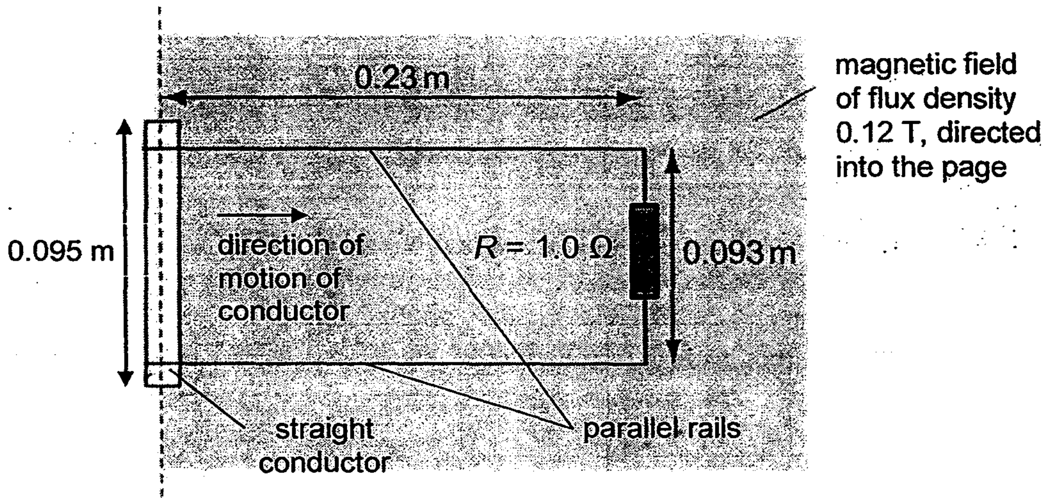


Which graph best represents how the induced e.m.f. E in the coil varies with time t?



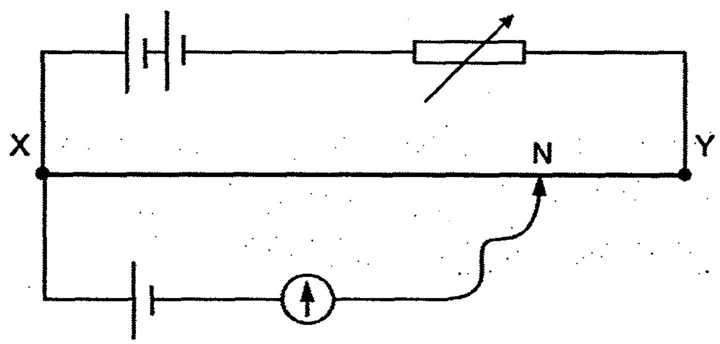
31 A straight conductor resting on two parallel rails, sweeps through a distance of 0.23 m in a uniform magnetic field in 1.00 s. The field has a flux density 0.12 T directed into the page.

Determine the magnitude and direction of the induced current flowing in the circuit.



	direction	magnitude
A	clockwise	2.57×10^{-3} A
B	clockwise	2.62×10^{-3} A
C	anti-clockwise	2.57×10^{-3} A
D	anti-clockwise	2.62×10^{-3} A

32 In the potentiometer circuit below, the moveable contact is placed at N on the bare resistance wire XY such that the galvanometer shows zero deflection.

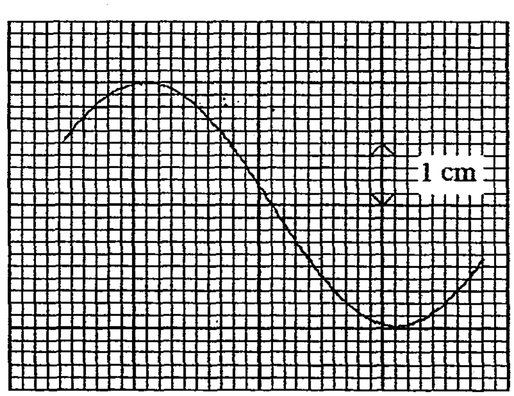


The resistance of the variable resistor is next increased.

What is the effect of increasing the resistance of the variable resistor on the potential difference across the wire XY, and on the position of the moveable contact for zero deflection on the Galvanometer?

	potential difference across XY	position of movable contact
A	increases	nearer to X
B	increases	nearer to Y
C	decreases	nearer to X
D	decreases	nearer to Y

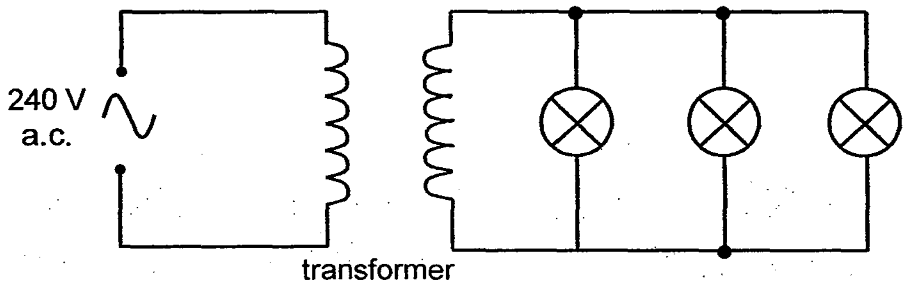
33 An alternating current passes through a resistor R of resistance 10 Ω. The potential difference across the resistor is measured by a C.R.O. The figure below shows the waveform on the screen. The y-sensitivity of the C.R.O. is 2.0 V cm^{-1}.



What is the average power dissipated in the resistor?

A zero **B** 0.40 W **C** 0.80 W **D** 1.6 W

34 A transformer has a 240 V a.c. input and a 12 V r.m.s. output. It is used to light three 12 V, 24 W lamps connected in parallel.



Assuming that the transformer is 100% efficient, what is the r.m.s. current in the primary circuit.

A 0.10 A **B** 0.30 A **C** 0.42 A **D** 6.0 A

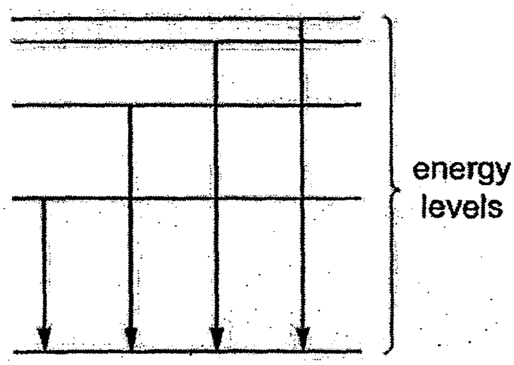
35 When an atom absorbs radiation of wavelength λ_1, it makes a transition from its ground state of energy E_1 to an excited state of energy E_3.

The atom then makes a second transition to a state of lower energy E_2, emitting radiation of wavelength λ_2.

What is the wavelength of the radiation emitted by the atom when it makes a third transition from its intermediate state of energy E_2 back to the ground state?

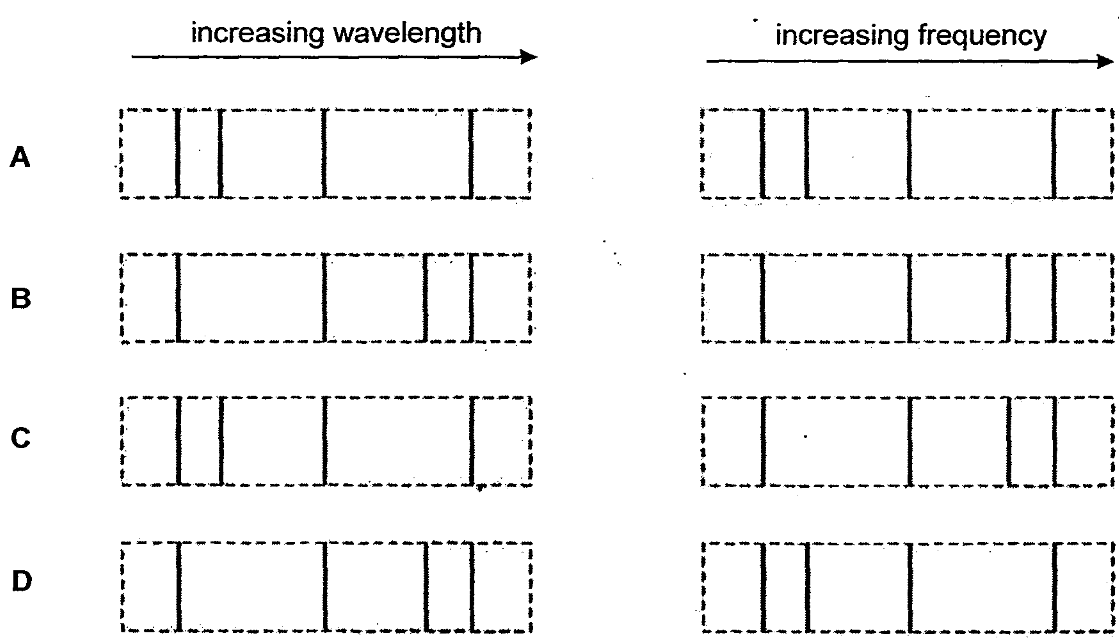
A $\lambda_1 - \lambda_2$ **B** $\lambda_2 - \lambda_1$ **C** $\dfrac{\lambda_1\lambda_2}{\lambda_1 - \lambda_2}$ **D** $\dfrac{\lambda_1\lambda_2}{\lambda_2 - \lambda_1}$

36 The diagram shows five electron energy levels in an atom and some transitions between them.



The line spectrum is in the visible spectrum and can be represented on a wavelength scale or a frequency scale.

Which diagram could represent the light emitted by the four transitions shown above?



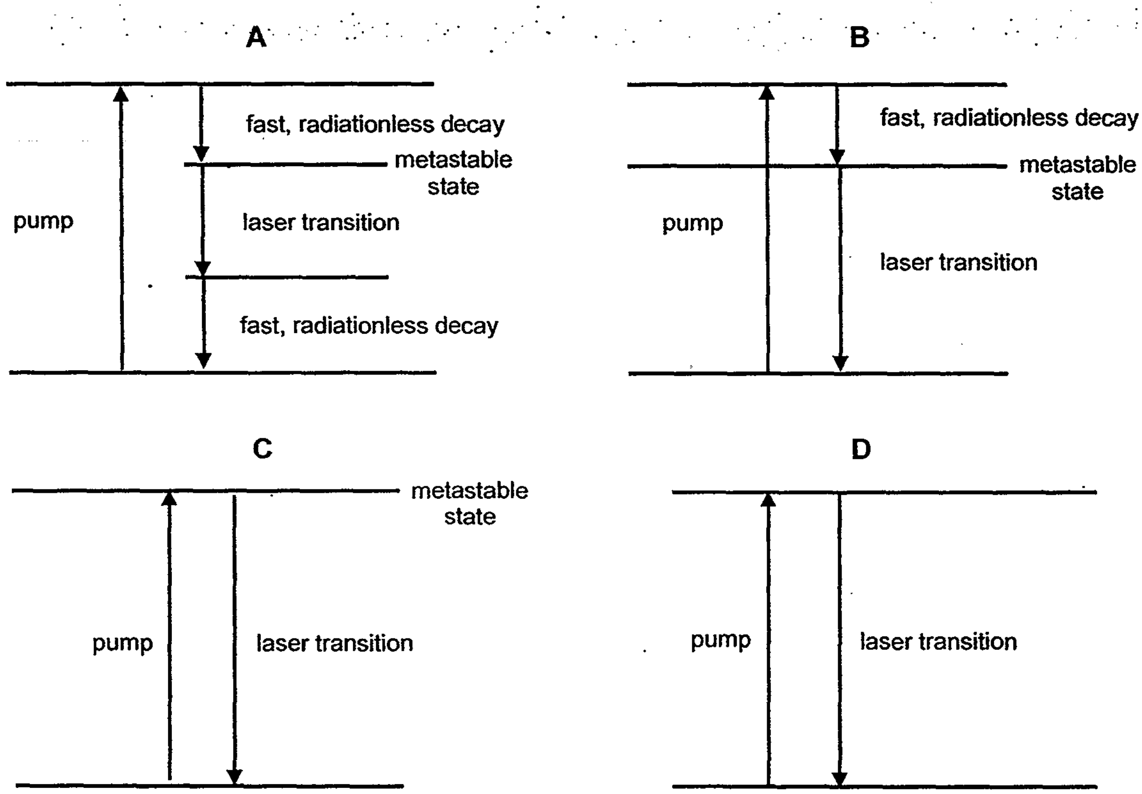
37 The energy level schemes of possible laser materials are shown in the four options below.

The "pump" refers to the excitation of the ground state atoms in the material.

The "fast, radiationless decay" refers to the de-excitation of an excited atom in which energy is transferred to the surrounding atoms as vibrational energy, without a photon produced.

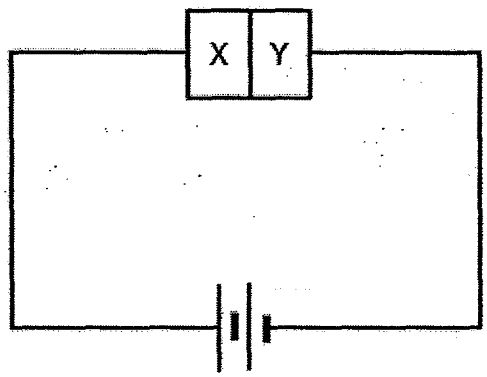
The "laser transition" refers to the de-excitation of an excited atom in which the desired laser photon is produced.

Which of the following energy level schemes best enable population inversion?



38 A semiconductor X is made by doping germanium crystal with arsenic (donor). Another semiconductor Y is made by doping germanium with indium (acceptor).

The two extrinsic semiconductors are next joined end-to-end, and connected to a battery as shown in the diagram below.



Which of the following statements is correct?

A X is p-type, Y is n-type and the battery is connected in forward bias.
B X is n-type, Y is p-type and the battery is connected in forward bias.
C X is p-type, Y is n-type and the battery is connected in reverse bias.
D X is n-type, Y is p-type and the battery is connected in reverse bias.

39 When α - particles are directed at a thin gold foil, it was observed that:

1. almost all the α - particles passed through the foil without deflection,
2. a few α - particles were deflected by large angles.

Which of the following best explains these observations?

	observation 1	observation 2
A	Most α - particles miss all the gold atoms.	A few α - particles bounced off the gold atoms.
B	The gold nucleus is very small so most α - particles missed all the gold nuclei.	Occasionally, the path of an α - particle approaches a gold nucleus sufficiently close to be deflected significantly.
C	Most α - particles had enough energy to pass straight through the gold foil.	Gold is very dense so the α - particles with low energy rebounded from the gold atoms.
D	The positive charge in an atom is distributed uniformly throughout the atom; it is not concentrated enough to deflect an α - particle.	Occasionally an α - particle experiences many small deflections in the same direction.

40 The nuclide Rn^{222}_{86} decays in a sequence of stages to form the nuclide Pb^{206}_{82}. Four of the nuclides formed in the sequence are α- particle emitters. The others are β- particle emitters.

How many nuclides formed in the decay sequence are β-particle emitters?

A 0 **B** 1 **C** 2 **D** 4

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2016 Prelim H2 Physics Paper 1 Solutions

Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans
1	A	11	C	21	D	31	A
2	B	12	A	22	A	32	D
3	B	13	C	23	C	33	C
4	A	14	B	24	C	34	B
5	D	15	D	25	A	35	D
6	B	16	A	26	A	36	C
7	C	17	C	27	C	37	A
8	D	18	D	28	D	38	D
9	D	19	B	29	C	39	B
10	C	20	A	30	D	40	D

10 A
7 B
11 C
12 D

1 **Solution: A**

Original question does not test on errors, hence modified.

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

Since $u = 0$, taking downwards to be positive

$$h = \frac{1}{2}gt^2$$

$$g = \frac{2h}{t^2}$$

$$\frac{\Delta g}{g} = \frac{\Delta h}{h} + 2\frac{\Delta t}{t}$$

$$= \frac{0.002}{0.785} + 2\left(\frac{0.0008}{0.4000}\right)$$

$$= 6.55 \times 10^{-3}$$

t affects the fractional uncertainty of g most.
Although the fractionalunceratinty of t is smaller than that of h,
the time is squared in the calculation of g,
hence its contribution to the fractional uncertainty of g is doubled.

2 **Solution: B**

Expressway has a speed limit of 90 km/hr. A typical car has a mass of 1000 kg.
Car's change in momentum = final momentum – initial momentum
= 0 – mv
=0 – (1000)(90x1000/3600)=-25000 kg m s^{-2} (B)

3	**Solution: B** **Modified** $v^2 = u^2 + 2as$ $0 = u^2 + 2as$ $u = \sqrt{-2as}$ for max safe speed, $u_{max} = \sqrt{-2a_{max}s}$ $= \sqrt{-2(-0.215)(1000)}$ $= 20.7 \text{ m s}^{-1}$ I.e. the speed of the train at the yellow signal has to be below 20.7 m s^{-1} otherwise the train either has to: (1) Undergo a larger deceleration than it can withstand, in order to stop within 1 km or (2) Still decelerate at 0.22 m s^{-2} but take more than 1 km to stop. Hence of the four options, B gives the maximum speed that train can pass by the yellow signal, and still stop within 1.0 km, while keeping the deceleration with 0.22 m s^{-2}.
4	**Solution: A** The area under a velocity-time graph over a certain time interval represents the change in displacement during the time interval. For the first half of the journey, the displacement is increasing with respect to time and for the second half of the journey, there is a negative change in displacement (i.e. the object moved backwards towards the reference point), so the graph shows a decreasing displacement.
5	**Solution: D** The force of P on Q and the force of Q on P are an action-reaction pair. Hence the two forces are equal in magnitude but opposite in direction. Alternatively, Total momentum before = Total momentum after $P_{initial,P} + P_{initial,Q} = P_{after,P} + P_{after,Q}$ $P_{after,Q} - P_{initial,Q} = -(P_{after,P} - P_{initial,P})$ $\Delta P_Q = -\Delta P_P$ Area under F-t graph for Q = −Area under F-t graph for P
6	**Solution: B** Newton's 2nd law defines the net force acting on an object as being directly proportional to the rate of change of momentum of the object, where the constant of proportionality is 1. Hence, from this definition, options A and C (rate of change of energy), and option D (Rate of change of force) can be eliminated.

	$F_{\text{exerted by wall on water jet}} = \frac{\Delta p_{\text{water}}}{\Delta t}$ = change in momentum of the water jet per unit time. $F_{\text{exerted by water jet on wall}} = -F_{\text{exerted by wall on water jet}}$ The magnitude of the force exerted by the water jet on the wall is equal to the force exerted by the wall on the water jet. Thus the magnitude of the force exerted by the water jet on the wall is numerically equa the change in momentum of the water jet per unit time.
7	**Solution: C** Upthrust is a net upward force due to the fluids. It arises from the fluid pressure differences. U = p_b (A) - p_t (A) = (p_b - p_t) (A)
8	**Solution: D** For a car travelling at constant speed, the net force acting on the car is zero. Consider the forces acting parallel to the slope, Sum of forces upward and parallel to slope = sum of forces downward and parallel to slope engine force = component of weight parallel to slope + resistive force engine force = $mg \sin \theta + F$
9	**Solution: D** Taking pivot at where W is acting, as L is moved outwards, the clockwise moment due to L is increased. To maintain rotational equilibrium, the anti-clockwise moment due to R has to increase. Hence, the perpendicular distance has to increase and R moves to the right.
10	**Solution: C** The work done against friction is converted to thermal energy. WD against friction = 60 x 10 = 600 J According to the work-energy theorem, the net work done on the crate = the change in KE of the crate. Net work done = F_{net} x S = (80-60)x 10 = 200 J
11	**Solution: C** $P = F_{engine} v$ Since car is travelling at constant speed, $P = F_{resistive} v$ $F_{resistive} \propto v^2$ $F_{resistive} = kv^2$ $(800) = k (20)^2$ k = 2

	$(F_{resistive}) = (2)(40)^2$ $F_{resistive} = 3200$ N $P = F_{resistive}\, v$ $P = (3200)(40)$ $P = 1.28 \times 10^5$ W
12	**Solution: A** Modified. KE at top of circle $= KE$ at bottom of circle $-$ gain in GPE $= \frac{1}{2}(1.27)(5.75^2) - (1.27)(9.81)(1.2)$ $= 6.044$ J Linear speed at top of circle: $\frac{1}{2}mv^2 = 6.044$ $v = 3.085$ m s^{-1} Tension at top, $T = F_C - mg$ $= \frac{(1.27)(3.085^2)}{0.6} - (1.27)(9.81)$ $= 7.689$ ≈ 7.69 N
13	**Solution: C** **Some options changed.** Statement A is wrong as a geostationary satellite can only remain vertically above a point above the Earth's equator. for constant ω, v is different for different r. Statement B is wrong since the period of the satellite is fixed at 24 hours, its orbital height is also fixed. Kepler's third law states that $T^2 = \frac{4\pi^2}{GM}R^3$ Statement D is wrong as the linear speed is not equal to that of the Earth. From $v = r\omega$,
14	**Solution: B** At r distance away, GPE, $-\frac{GMm}{r} = -3.2$ MJ At $2r$ distance away, for the second satellite, GPE $-\frac{GMm}{2r} = -(1/2) \times 3.2$ MJ

$= -1.6$ MJ

Since KE = ½ |GPE| = ½ (1.6 MJ)
= 0.8 MJ

Total energy of the second satellite, E = KE + EPE = 0.8 MJ + (– 1.6 MJ)
= – 0.8 MJ

15 **Solution: D**

Speed, $v = \omega \sqrt{(x_o^2 - x^2)}$,
At x = 0
$v = \omega\,(x_o)$
$= 2\pi\,(319)\,(0.50 \text{ mm})$
$= 1002 \text{ mm s}^{-1}$
$= 1000 \text{ mm s}^{-1}$ (3 sf)

16 **Solution: A**

Fact. A larger damping effect will cause all the amplitudes to be reduced at all frequencies.

17 **Solution: C**

mL = Pt
(1): $L = Pt_1 / m$

$mc\Delta\theta = Pt$
(2): $c = Pt_2 / m\Delta\theta$

$$\frac{(1)}{(2)}: \frac{L}{c} = \frac{Pt_1}{m} \div \frac{Pt_2}{m\Delta\theta}$$

$$= t_1 \times \frac{\Delta\theta}{t_2} = 40 \times 4.0 = 160K$$

18 **Solution: D**

$p = 1/3 \text{ (density) } <c^2>$

$$\sqrt{<c^2>} = \sqrt{\frac{3p}{(density)}}$$

$$= \sqrt{\frac{3(1.00 \times 10^5)}{(1.6)}} = 433 \text{ m s}^{-1}$$

19 **Solution: B**

$$\frac{\Delta\theta}{2\pi} = \frac{\Delta x}{\lambda} \quad \Rightarrow \quad \frac{\pi/3}{2\pi} = \frac{0.40}{\lambda}$$

Since phase difference of $\frac{\pi}{3}$ = 0.40 m, the wavelength = 0.40 x 6 = 2.40 m

Thus, speed = $f\lambda$ = 200 x 2.40 = 480 ms^{-1}

20 **Solution: A**

The sound generated by the vibrating string is a *progressive* longitudinal wave.

21	**Solution: D** At the 1st order bright fringe, the waves meet at in phase with the phase difference of 2π. From the graph, $Distance\ x\ of\ 1st\ order\ bright\ fringe\ from\ C = 2.4\ mm$ (phase diff 2π) $Distance\ CP, \Delta x = 4.2\ mm$ (phase diff $\Delta\theta$) Using ratio, $\frac{\Delta\theta}{2\pi} = \frac{\Delta x}{x}$ $Phase\ angle\ at\ Q = \frac{4.2}{2.4} \times 2\pi = \frac{7}{2}\pi$ Equivalent phase difference $= \left(\frac{7}{2}\pi - 2\pi\right) = \frac{3}{2}\pi\ (principle\ value)$
22	**Solution: A** Use formula for diffraction grating: $d \sin\theta = n\lambda$ $d = 10^{-3}$ m / 625 = 1.60×10^{-6} m n = 1 $\theta = 20°$ $(1.60 \times 10^{-6}) \sin 20° = (1)(\lambda)$ $\lambda = 5.47 \times 10^{-7}$ m = 550 nm (2 s.f.)
23	**Solution: C** A: see explanation for C B: see explanation for C C: negative ion is initially projected into the in the same direction as the electric field. After some time, the negative ion will de-celerate and changes the magnitude and direction of the velocity. D: negative ions accelerate in the opposite direction to the electric field.
24	**Solution: C** Electric field strength, $E = \frac{\Delta V}{\Delta d} = \frac{12}{1.0 \times 10^{-3}} = 12000\ NC^{-1}$ Work done, $W = q\,\Delta V = (3.9 \times 10^{-6})(12) = 4.7 \times 10^{-5}$ J
25	**Solution: A** Question changed, unclear. At 0.10 A, the p.d. across the resistor is 1 V, and the p.d. across the thermistor is 2 V. The today p.d. is thus 3 V which is equal to the emf of the cell. ~~Same current through both components. Hence use graph to find a value of current where the 2 pd add up to 3.0 V → 0.1 A~~ ~~To maintain same current with doubled resistance of resistor, pd across resistor is 2.0~~

	~~V. Hence new e.m.f is 2.0 + 2.0 = 4.0 V~~
26	**Solution: A** Q = It = 0.50(1000) = 500 C E = W/Q = 4500/500 = 9.0 V
27	**Solution: C** Modify question so that students will not make use of Emf calculated in previous question otherwise double penalise if wrong. Energy dissipated in variable resistor = P x t =I^2Rt =$(0.50)^2(16)(1000)$ =4000 J Thus energy dissipated due to internal resistor will be 500 J. ~~I = E/(R+r) = 9.0/(16+r) = 0.50~~ ~~r = 2.0 Ω~~
28	**Solution: D** Originally: $R_{total} = \left(\frac{1}{2R} + \frac{1}{2R}\right)^{-1} = R$ $I_{total} = \frac{E}{R}$ $I_P = I_Q = I_R = I_S = \frac{E}{2R}$ $P_P = P_Q = P_R = P_S = \left(\frac{E}{2R}\right)^2 R = \frac{E^2}{4R}$ Final: $R_{total} = \left(\frac{1}{R} + \frac{1}{R}\right)^{-1} + R = \frac{3R}{2}$ $I_{total} = \frac{2E}{3R}$ $P_R = \left(\frac{2E}{3R}\right)^2 R = \frac{4E^2}{9R}$ $P_Q = P_S = \left(\frac{E}{3R}\right)^2 R = \frac{E^2}{9R}$ Hence P brighter, Q and S dimmer
29	**Solution: C** At A, both the magnetic fields of X and Y are directed upwards. Hence the field would be non-zero. At D, both the magnetic fields of X and Y are directed downwards. Hence the field would also be non-zero.

	At B, both the magnetic fields of X and Y are directed opposite to each other but do not cancel out each other as the field due to X (which is closer) will be stronger than the field due to Y. Hence the field would also be non-zero At option C, both the magnetic fields due to X and Y are equal in magnitude but opposite in direction. Thus the net field will be 0.
30	**Solution: D** When magnet is at the **starting position**, the **speed is close to zero**, the **magnetic field is also weak**, hence the **change in flux linkage and thus the induced emf is close to 0.** (Eliminate Option C). When the **magnet passes through centre of the coil**, the **speed is large**, but the **change in magnetic flux linkage is small (as the strength of the magnetic field is about constant**, thus the induced emf is also close to zero. When magnet leaves coil, and is **far from coil, speed is large**, but **B-field is very weak** thus the **change in magnetic flux linkage is very small**, the induced emf is close to 0. (Eliminate Option A) We expect the **induced emf to be of opposite polarity** when the **magnet enters and leaves the coil** thus we can eliminate **option B and the answer is option D.**
31	**Solution: A** Induced emf, $E_{\text{induced}} = Blv = (0.12)(0.093)(0.23) = 2.57 \times 10^{-3}$ V Alternatively: $E_{\text{induced}} = -\frac{\Delta\Phi}{\Delta t} = -\frac{\Phi_{\text{final}} - \Phi_{\text{initial}}}{\Delta t} = -\frac{0-(0.12)(0.093)(0.23)}{1.0} = 2.57 \times 10^{-3}$ V Induced currrent $I = \frac{E_{\text{induced}}}{R} = \frac{2.57 \times 10^{-3}}{1.0} = 2.57 \times 10^{-3}$ A The flux linkage through the circuit is decreasing. Hence current will flow in the clockwise direction, generating an induced B-field into the page, to oppose the decrease in flux linkage.
32	**Solution: D**

	By potential divider concept, pd across increased resistance will increase, hence pd across XY will decrease. In order to maintain zero deflection, total pd tapped should remain unchanged. Hence longer length needed (towards Y)
33	**Solution: C** $\langle P \rangle = \frac{1}{2} V_o^2/R = \frac{1}{2} \times 42/10 = 0.80$ W
34	**Solution: B** Power for 3 lamps = 3 × 24 = 72 W Input current = 72 W / 240 V = 0.30 A
35	**Solution: D** $(E_3 - E_1) = (E_3 - E_2) + (E_2 - E_1)$ $\frac{hc}{\lambda_1} = \frac{hc}{\lambda_2} + \frac{hc}{\lambda_3}$ $\frac{1}{\lambda_3} = \frac{1}{\lambda_1} - \frac{1}{\lambda_2} = \frac{\lambda_2 - \lambda_1}{\lambda_1 \lambda_2}$ $\lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_2 - \lambda_1}$
36	**Solution: c** **Changed original question on Heisenberg uncertainty.** Lines at the high energy end i.e. high frequency or low wavelength, are closer together as the difference in energy is smaller. Lines at the low energy end i.e. low frequency or large wavelength are further apart due to the larger difference in energy.
37	**Solution: A** The fast decay transitions in scheme A facilitates population inversion best because it causes the upper lasing level to be populated and the lower lasing level to be emptied quickly. The ground state can never be totally emptied hence option B and C is non-ideal. Option C and option D have only two energy levels, 2-states lasers are not possible. In fact for option D, population inversion is not possible.
38	**Answer: D** Donor → more electrons as charge carriers, thus X is n-type Acceptor → more holes as charge carriers, thus Y is p-type In this connection, the n-type semiconductor is connected to positive terminal while the p-type semiconductor is connected to the negative terminal. The external E field will reinforce the internal one, thus no current will flow as depletion region expands → **reverse bias**
39	**Solution: B**

	On the reason for 1, the α - particles **do not miss** the gold atoms but rather the **atoms are made up of mostly empty space**, hence most of the α - particles would **miss the nuclei instead.** Occasionally, an α - **particle comes sufficiently close to the nucleus**, and is **deflected by the positively-charged nucleus**. Hence, it is **not very accurate** to say the α **- particles bounce off the gold atoms or the gold surface.**
40	**Solution: D** $Rn^{222}_{86} \rightarrow Pb^{206}_{82} + 4\,He^{4}_{2} + 4\,e^{0}_{-1}$ Since four beta particles produced, four of the intermediate daughter nuclides must have been beta-emitters.