H2 PHYSICS

Exam papers with worked solutions

(Selected from Top JC)

SET B

PAPER 1

Answer

Compiled by

THE PHYSICS CAFE

1 Penelope measures the mass and speed of a glider. The percentage uncertainty in her measurement of the mass is 3% and in the measurement of the speed is 10%. Her calculated value of the kinetic energy of the glider will have an uncertainty of

A 10% **B** 13% **C** 23% **D** 30%

Ans: C

$\frac{\Delta KE}{KE} = \frac{\Delta M}{M} + 2\frac{\Delta v}{v} = 0.03 + 2(0.10) = 0.23$ thus percentage uncertainty = 23%

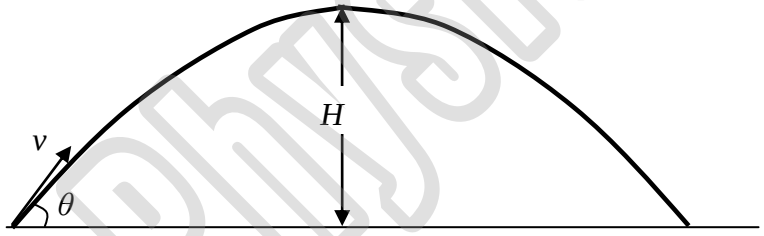
2 The size of an atom is of the order of magnitude of

A 10^{-6} m **B** 10^{-8} m **C** 10^{-10} m **D** 10^{-14} m

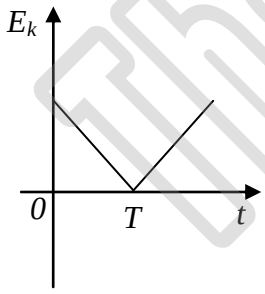
Ans: C

The *nucleus* of the atom has a diameter of about 10^{-15} m, whereas the *atomic* diameter is about 10^{-10} m.

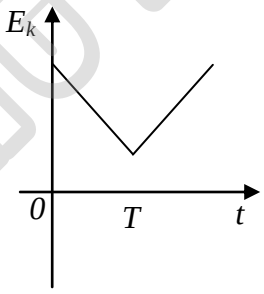
3 A ball was projected from the ground with a velocity v at an angle θ to the horizontal. It traces a parabolic path as shown below, reaching a maximum height H after a time T and then falls back down to the ground. Air resistance may be assumed to be negligible. Which graph best shows the variation of kinetic energy E_k of the ball with time t?



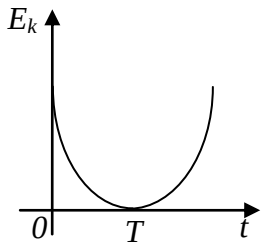
A



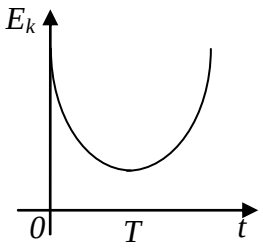
B



C



D



Ans: D

Note that at maximum height, the ball still has a speed of $v \sin\theta$. Hence E_k E is not equals to zero at $t = T$. Options A and C are out.

KE due to horizontal velocity = constant → horizontal line --------- (1)

Vertically, v = u + at
KE due to vertical velocity = ½ m $(u + at)^2$ → quadratic curve --------- (2)

Summing up (1) and (2), our answer is D.

4 A stationary 1800 kg truck is hit from behind by a 900 kg car. The two become entangled and move off at the same speed together. If the smaller car was moving at a speed of 20 m s^{-1} initially, what is the final speed of the two vehicles after the collision?

A 4.20 m s^{-1}
B 6.67 m s^{-1}
C 8.33 m s^{-1}
D 9.10 m s^{-1}

Ans: B

$$(900)(20) = (1800 + 900)(v)$$
$$v = 6.67 ms^{-1}$$

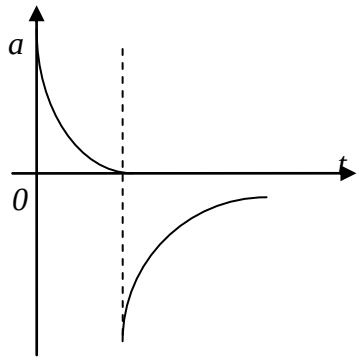
5 Two satellites collide in space inelastically. What happens to the *kinetic energy* and *momentum* of the system of the two satellites?

	Kinetic energy	***Momentum***
A	Conserved	Conserved
B	Conserved	Reduced
C	Reduced	Conserved
D	Reduced	Reduced

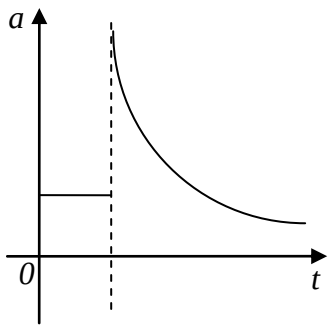
Ans: C

6 A stone was thrown vertically upwards and subsequently falls into a pond. Which graph best represents the variation of the stone's acceleration *a* with time *t*? Assume air resistance to be negligible.

A

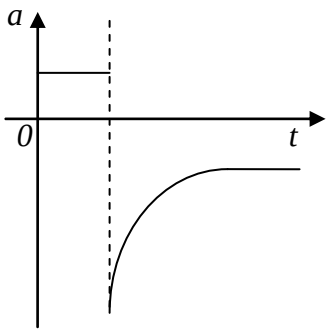


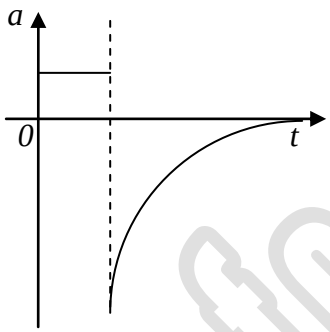
B



C

D

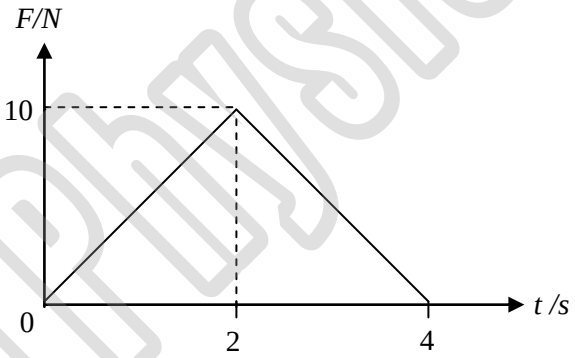




Ans: D

Before impact with water, *downward* acceleration a = g = constant
At point of impact with water, *upward* acceleration is maximum.
As stone slows down, drag force decreases, hence magnitude of acceleration decreases.
When drag force + upthrust = weight, a = 0 (i.e. terminal velocity reached).
Here, vectors downward taken as positive.

7 The graph below shows the force acting on a body of 2 kg over a period of 4 s.



If the body was initially moving at 1 m s^{-1}, what would be its velocity after 4 s?

A 10 m s^{-1} **B** 11 m s^{-1} **C** 20 m s^{-1} **D** 22 m s^{-1}

Ans: B

Total change in momentum = area under graph = ½ (4)(10) = 20 kg m s^{-1}
$p_f = p_i + \Delta p = (2)(1) + 20 = 22$ kg m s^{-1}
$v_f = 22 / 2 = 11$ m s^{-1}

8 A particle of mass *m* slides down an inclined plane with an average acceleration *a*. The inclined plane makes an angle θ with the horizontal. The average frictional force exerted by the plane on the mass is

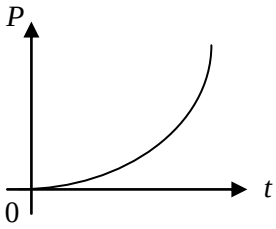
A $m(g - a)$ **B** $m(g + a) \sin \theta$ **C** $m(g - a) \sin \theta$ **D** $m(g \sin \theta - a)$

Ans: D

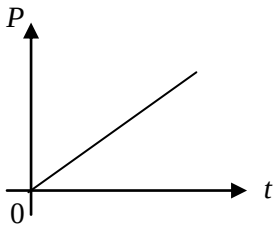
mg sin θ – f = ma
f = m(g sin θ – a)

9 An object resting on a horizontal frictionless surface is accelerated from rest by a constant force from a motor. Which of the following graphs shows the variation of the motor power *P* with time *t*?

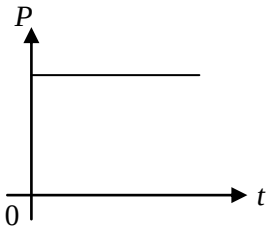
A



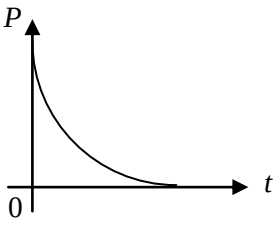
B



C



D



Ans: B

P = Fv = F(u + at) = F(0 + at) = Fat
Since F and a are constants, P varies linearly with t.

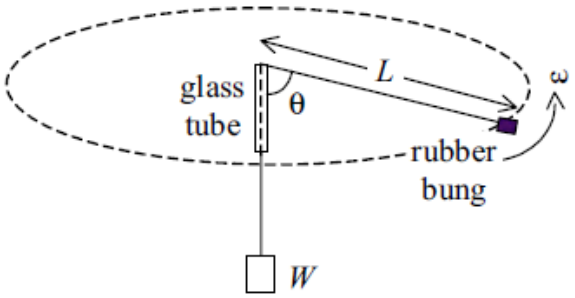
10 An electric motor is required to haul a cage of mass 400 kg up a mine shaft through a vertical height of 1000 m in 3 minutes. What will be its electrical power required if its overall efficiency is 87%?

A 2.55 kW **B** 19.0 kW **C** 21.8 kW **D** 25.1 kW

Ans: D

Power output = mgh / t = (400 x 9.81 x 1000) / (3 x 60) = 21800 W = 21.8 kW
Power output/Power input = 0.87
Power input = Power output / 0.87 = 21.8 / 0.87 = 25.1 kW

11 A student performing an experiment whirls a rubber bung attached to one end of a string which passes through a glass tube with smooth openings and has a weight W hanging at its other end. The weight of the rubber bung is much smaller than W. The rubber bung is set into a horizontal uniform circular motion with angular speed ω while the length of the string beyond the upper opening of the glass tube is L and this portion of the string makes an angle θ with the vertical as shown.



Which of the following statement(s) is/are correct?

(1) If L is kept constant, θ will decrease as ω is increased.
(2) If θ is kept constant, L will increase as ω is increased.
(3) When W is increased, θ will increase.

A (1) only
B (2) only
C (3) only
D (2) and (3) only

Ans: C

Vertically,
$T \cos \theta = mg$ --- (i)

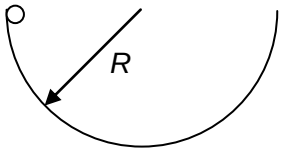
Horizontally,
Centripetal force = $T \sin\theta = m(L \sin\theta)\omega^2$
$T = mL\omega^2$ --- (ii)

From (ii): When ω is increased and L is kept constant → T increased
From (i): T increased → cos θ must decrease, since mg unchanged →θ must increase. Hence (1) is false.

From (i): θ kept constant → T kept constant, since mg unchanged.
From (ii): If ω is increased and θ is kept constant (and hence T is kept constant), L must decrease. Hence (2) is false.

When W is increased, the tension in the string increases and hence a smaller of its vertical component is needed to balance the weight of the rubber bung. Hence θ will increase.
i.e. $T \cos \theta = mg$
When T increases, since mg unchanged, θ must increase. Hence (3) is true.

12 A marble of mass 20 g is released from rest from the rim of a semi-circular bowl of radius R. Determine, in newtons, the normal reaction force exerted by the bowl on the marble when the marble is at the bottom of the bowl.



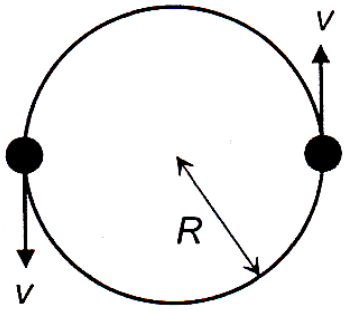
A 0.2 **B** 0.4 **C** 0.6 **D** 0.8

Ans: C

By C.O.E., $mgR = \frac{1}{2} mv^2 \rightarrow mv^2 = 2mgR$

At the bottom of the bowl,
$N - mg = mv^2 / R = 2mgR / R = 2mg$
$N = 3mg = 0.6$ N

13 Two stars of equal mass *M* move with constant speed *v* in a circular orbit of radius *R* about their common centre of mass as shown in the diagram below.



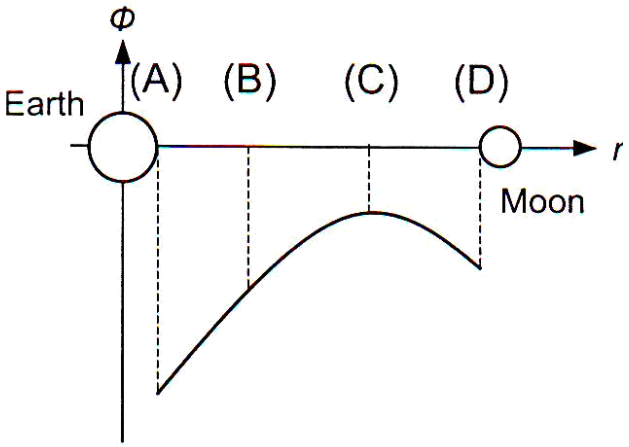
What is the net force on each star?

A $\frac{GM^2}{4R^2}$ **B** $\frac{Mv^2}{2R}$ **C** zero **D** $\frac{2Mv^2}{R}$

Ans: A

Just apply Newton's Law of gravitation to the two stars.

14 The diagram below shows how the gravitational potential varies between the moon and Earth. At which position will a particle experience zero net force?



Ans: C

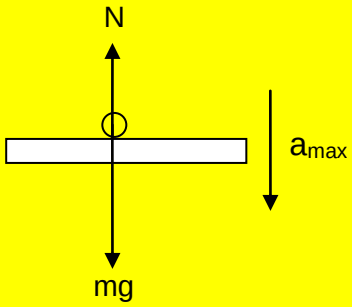
Since $g = -d\Phi/dr$. At C, gradient = 0 → g = 0 → $F_G = mg = 0$.

This is the point where the gravitational field due to Earth cancels out the gravitational field due to the Moon so that the resultant gravitational field strength g is zero.

15 An object placed on a horizontal platform is vibrating vertically in simple harmonic motion with a frequency of 2.0 Hz. The maximum amplitude of oscillation that will allow the object to remain in contact with the platform throughout the motion is

A 0.78 cm **B** 1.6 cm **C** 2.5 cm **D** 6.2 cm

Ans: D



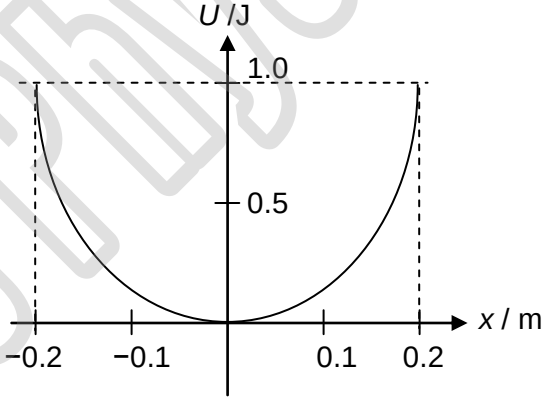
Take vectors upwards as positive,
$N - mg = m(-a_{max})$

To find max. ampliltude, set N=0 at $x = x_o$

Hence $a_{max} = g$

For SHM, $a_{max} = \omega^2 x_o$
Hence $x_o = g / \omega^2 = g / (2\pi f)^2 = 9.81 / (4\pi)^2 = 6.2$ cm

16 A particle of mass 4 kg moves with simple harmonic motion and its potential energy *U* varies with position *x* as shown in the diagram.



What is the period of oscillation of the mass?

A 0.56 s **B** 1.78 s **C** 1.00 s **D** 2.50 s

Ans: B

$U = ½ kx^2 = ½ m\omega^2x^2$
$(1.0) = ½ (4)(\omega^2)(0.2)^2$
$\omega^2 = 12.5 \rightarrow (2\pi/T)^2 = 12.5 \rightarrow T = 1.78$ s

The Physics Cafe

17 A metal block **X**, of mass *m,* at 0°C comes into contact with another metal block **Y**, of mass 2*m*, at 100 °C. Heat conduction takes place with no loss to the surroundings. The final equilibrium temperature of the blocks is 20 °C. If the specific heat capacities of the two metals are c_x and c_y respectively, then

A $c_x = 8\,c_y$ **B** $c_x = 4\,c_y$ **C** $c_x = 2\,c_y$ **D** $c_x = ½\,c_y$

Ans: A

Heat loss by Y = Heat gain by X
$(2m)c_Y(100 - 20) = mc_X(20 - 0)$
$160\,c_Y = 20\,c_x \rightarrow 8\,c_Y = c_x$

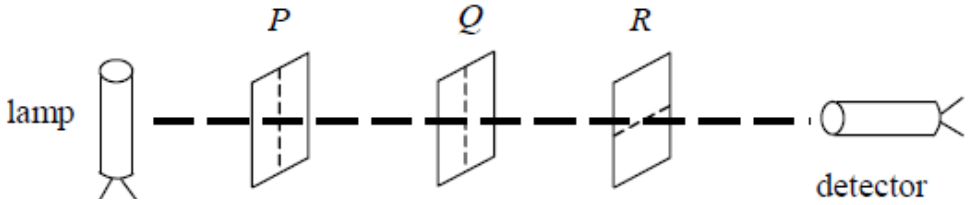
18 An ideal gas has an initial volume of 1.2×10^{-3} m^3 and at a pressure of 1.0×10^5 Pa. When 80 J of energy is supplied to the gas, its volume increases to 1.5×10^{-3} m^3 while its pressure remains constant. As a result, the internal energy of the gas is

A increased by 110 J **B** increases by 80 J **C** increases by 50 J **D** decreases by 50 J

Ans: C

$W = -p\,\Delta V = -(1.0 \times 10^5)(1.5 - 1.2)(10^{-3}) = -30$ J
$\Delta U = Q + W = (+80) + (-30) = +50$ J

19 Three polaroid sheets P, Q and R are placed along a straight line with a lamp and a detector as shown.



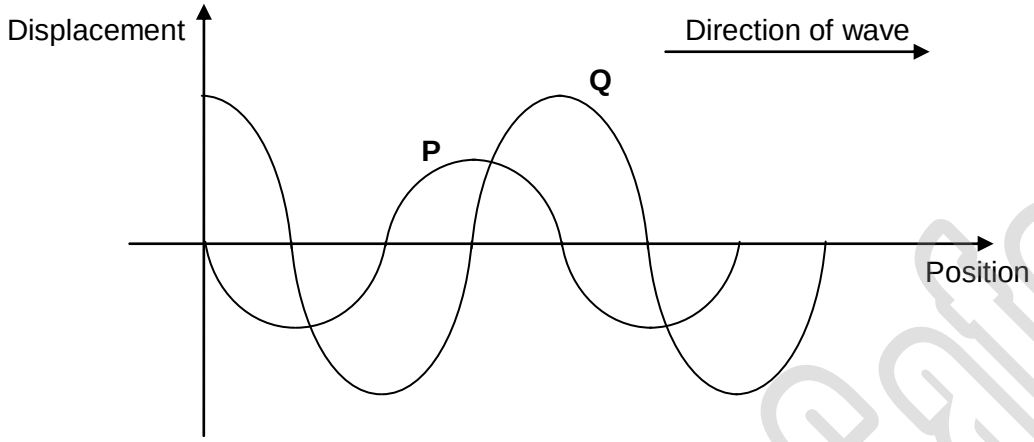
Initially the directions of polarization of P and Q are parallel but are both normal to that of R. What happens to the intensity *I* recordered by the detector when P is being rotated slowly through 90° until its direction of polarization is parallel to that of R?

A *I* remains unchanged.
B *I* increases throughout.
C *I* increases and then decreases.
D *I* decreases and then increases.

Ans: A

Since the polarizing axis of Q and R remains perpendicular to each other throughout, intensity I remains constant at zero throughout.

20 Two waves **P** and **Q** are moving towards the right as shown in the figure below.



Which of the following correctly describes the phase difference between the two waves?

A P lags Q by $\frac{\pi}{4}$ radians.

B P leads Q by $\frac{\pi}{4}$ radians.

C P lags Q by $\frac{3\pi}{2}$ radians.

D P leads Q by $\frac{3\pi}{2}$ radians.

Ans: D

Q leads P by $\frac{\pi}{2}$ rad. Equivalently, P leads Q by $\frac{3\pi}{2}$ rad.

21 A beam of white light was projected onto a diffraction grating with 500 lines per mm. How many orders of the entire visible spectrum (400 nm – 700 nm) can it produce?

A 2 **B** 3 **C** 4 **D** 5

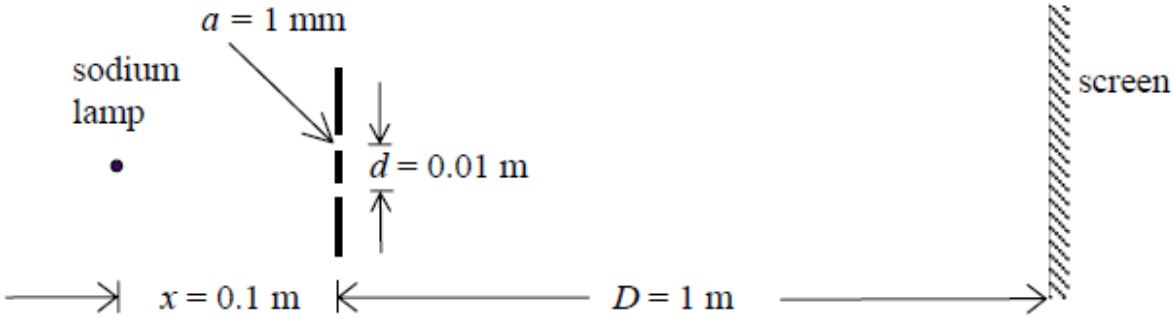
Ans: B

$d\sin\theta = m\lambda$
$(0.001/500)\sin\theta = m(700 \times 10^{-9})$
Note: Use λ = 700 nm not 400 nm since the longer wavelength light will be diffracted more. Hence on the screen, we will observe more orders of bright fringes corresponding to the shorter wavelength light. Hence the number of COMPLETE spectrums we will observe is limited by the longer wavelength light.

To find the max. order, $\sin\theta = 1$
→ m = 2.9 → max order = 2
Including the zeroth order, total number of orders of entire visible spectrum seen = 2 + 1 = 3.

The Physics Cafe

22 A student prepares a double-slit set-up as shown below. However, no interference fringe can be observed on the screen.



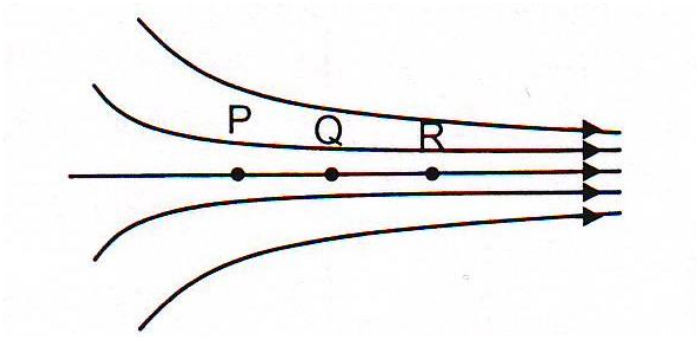
A suitable improvement may be

A using a mercury lamp to provide radiation of a shorter wavelength.
B reducing *x*.
C reducing *d*.
D increasing *a*.

Ans: C

For observable diffraction, λ >> d and λ >> a.

23 The diagram below shows electric field lines with points PQR on one of the field lines. The distance PQ=QR. If the potential at P is 0V and the potential at Q is -200V, what is a possible value of the potential at R?

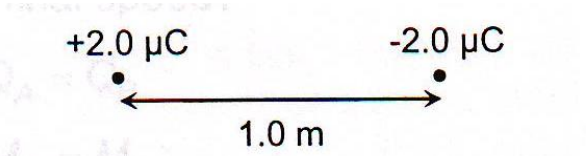


A -450 V **B** -400 V **C** -350 V **D** +200 V

Ans: A

Field lines are narrowing, meaning increasing field strength.
Since E = - dV/dx, potential gradient is steeper between Q and R than between P and Q.
Hence the potential drop from Q to R is greater than that from P to Q. Only possible answer is -450 V.

24 Determine the electric field strength at the mid-point between the two charges below.



A 0 Vm^{-1} **B** 3.6 x 10^4 Vm^{-1} **C** 7.2 x 10^4 Vm^{-1} **D** 1.4 x 10^5 Vm^{-1}

Ans: D

$$E = \frac{1}{4\pi(8.85\times10^{-12})}\frac{2\times10^{-6}}{(0.5)^2} + \frac{1}{4\pi(8.85\times10^{-12})}\frac{2\times10^{-6}}{(0.5)^2} = 143868.875 Vm^{-1} = 1.4\times10^5 Vm^{-1}$$

25 A battery, during its usable lifetime, supplies a constant current of 40 μA to a clock for 800 days. How much charge does the battery supply during this time?

A 20 μC **B** 32 000 μC **C** 46 C **D** 2800 C

Ans: D

Q = It = 40 x 10^{-6} A x 800 x 24 x 60 x 60 = 2764.8 C ≃ 2800 C

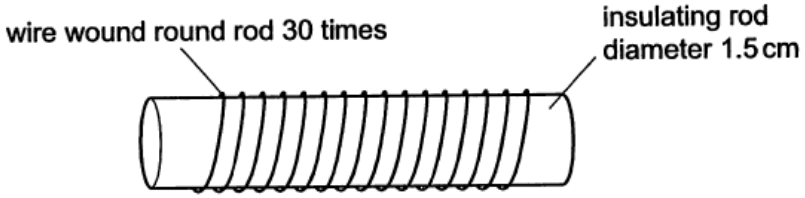
26 A generator produces 100 kW of power at a p.d. of 10 kV. The power transmitted through cables of total resistance 5Ω. What is the power loss in the cables?

A 50 W
B 250 W
C 500 W
D 1000 W

Ans: C

Current passes through the circuit is I=P/V = 100 kW/10 kV = 10 A
Power loss in the cables is = I^2R = 10 x 10 x 5 = 500 W

27 The material of a wire has resistivity 1.3 x 10^{-8} Ωm. The wire has diameter 0.50 mm and its length is just enough to enable it to be wound tightly round an insulating rod 30 times. The rod has diameter 1.5 cm.



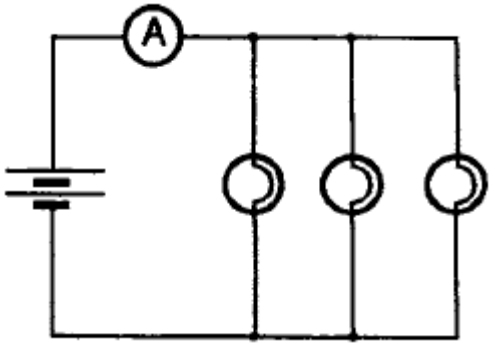
What is the resistance of the wire?

A 1.1 x 10^1 Ω **B** 9.4 x 10^{-2} Ω **C** 7.0 x 10^{-4} Ω **D** 1.1 x 10^{-5} Ω

Ans: B

The length of the wire is $(2\pi D/2)(N) = \pi DN$
The cross-sectional area is $\pi d^2/4$
Resistance = $\rho L/A = \rho(\pi DN) / (\pi d^2/4) = 4\rho DN/d^2$
$= 4\ [(1.3 \times 10^{-8}\ \Omega m)(1.5/100\ m)(30)] / [(0.5/1000)(0.5/1000)]$
$= 9.4 \times 10^{-2}\ \Omega$

28 Three similar light bulbs are connected to a constant-voltage d.c. supply as shown in the diagram. Each bulb operates at normal brightness and the ammeter (of negligible resistance) registers a steady current.



The filament of one of the bulbs breaks. What happens to the ammeter reading and to the brightness of the remaining bulbs?

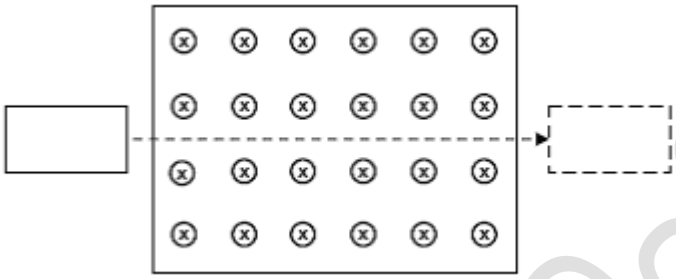
	Ammeter reading	Bulb brightness
A	Increases	Increases
B	Increases	Unchanged
C	Unchanged	Unchanged
D	Decreases	Unchanged

Ans: D.

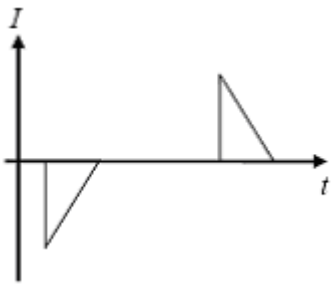
When one filament breaks, total circuit resistance increases from R/3 to R/2. Hence ammeter reading decreases.

Since bulbs are connected in parallel, voltage across each remains the same when there is one less bulb. Power dissipated by each bulb, given by $P = V^2/R$, remains unchanged.

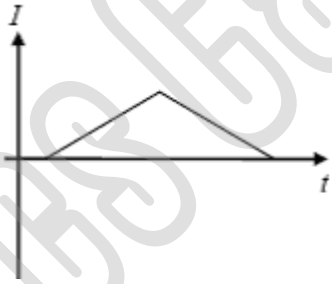
29 The figure below shows a rectangular metal frame entering a region of uniform magnetic field. Given that the plane of the metal frame is always normal to the magnetic field, and that the metal frame moves at a constant speed, which graph below best shows the variation with time t of the current I induced in the frame.



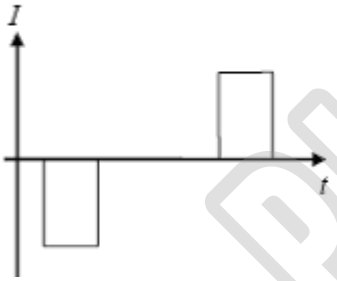
A



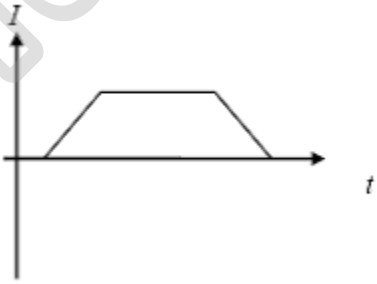
B



C



D



Ans: C

When the coil is **fully** in the magnetic field, there is no change in flux and it there is no induced emf/current. When the coil is entering / exiting the magnetic field, the rate of change of flux linkage is constant, hence the induced emf should be constant, albeit in an opposite direction.

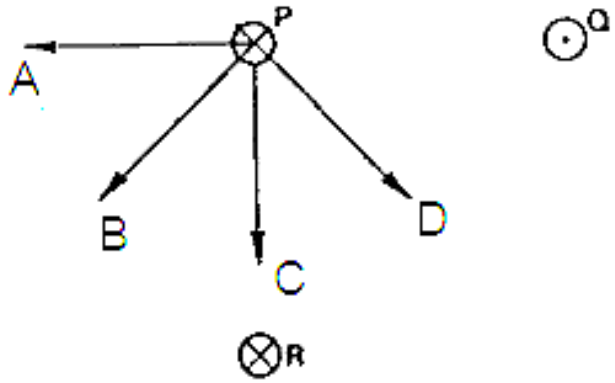
30 A horizontal straight wire of length 2 m is raised vertically through a height of 3.0 m in 0.20 s. The horizontal component of the Earth's magnetic field strength at this location is 2.0×10^{-5} T, while the vertical component at this location is 8.0×10^{-7} T. What is the average e.m.f. induced across the ends of the wire?

A zero **B** 0.024 mV **C** 0.12 mV **D** 0.60 mV

Ans: D

Induced EMF = Blv = $(2.0 \times 10^{-5})(2)(3 / 0.20) = 0.60$ mV

31 The diagram shows three long straight wires P, Q and R normal to the plane of the paper. Wires P and R carry currents directed into the plane of the paper, and wire Q carries a current directed out of the paper. All three currents have the same magnitude.



Which arrow best shows the direction of the resultant force on wire P ?

Ans: B

Direction of resultant field due to current R and Q at P is in direction of D. Using Fleming's Left Hand Rule, the force is in direction B.

32 A charge moves in a circular orbit in a uniform magnetic field.
Which one of the following statements is correct?

A The force on the charge is parallel to the field.
B The period in the orbit is independent of the speed of the charge.
C The momentum of the charge is independent of the circle radius.
D The radius of the circle is directly proportionate to the charge.

Ans: B

Manipulating $Bqv = mv^2 / r$ gives $Bqr = mv$ → hence C is wrong.
Manipulating $Bqr = mv = mr\omega = mr(2\pi/T)$ gives $T = 2\pi m / Bq$ → hence B is correct.

33 A steady current I dissipates a certain power in a variable resistor. The resistance has to be halved to obtain the same power when a sinusoidal alternating current is used.

What is the r.m.s. value of the alternating current?

A ½ I
B √½ I
C I
D √2 I

Ans: D

$I^2 R = I'^2 (R/2)$
$I'^2 = 2 I^2$
$I' = \sqrt{2}\ I$

34 The power dissipated in a light bulb connected across an a.c. source of peak voltage 180 V is 50 W. If two such light bulbs are connected in series to the electrical mains of 230 V r.m.s., what would be the total power dissipated in both the lamps?

A 50.6 W **B** 81.6 W
C 100 W **D** 61.6 W

Ans: B

Since V_o = 180 V, $V_{rms} = 180/\sqrt{2}$.
$R = V_{rms}^2 / P = (180/\sqrt{2})^2 / 50 = 324\ \Omega$.
Power dissipated in one light bulb is = $V^2/R = (230 / 2)^2 / 324 = 40.8$ W
Power dissipated in two light bulbs is = 40.8 x 2 = 81.6 W.

35 A spectrometer is set up to observe the spectrum produced by the sodium lamp as shown in Figure 36.1. The energy levels of the lowest states of sodium are given in Figure 36.2.

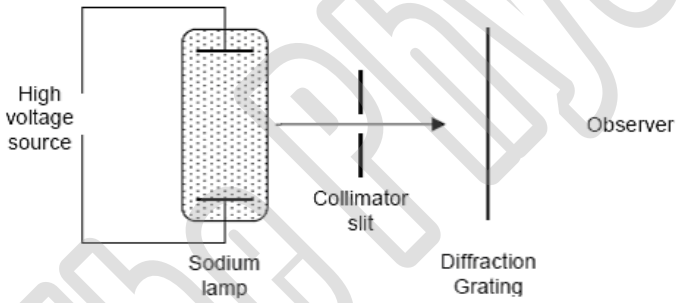


Figure 36.1

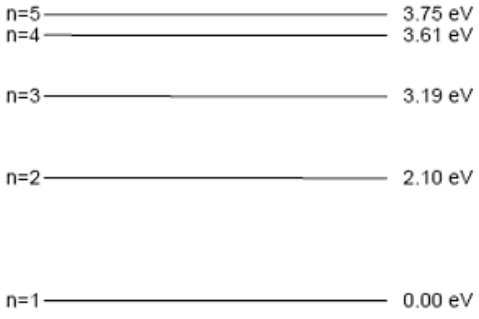


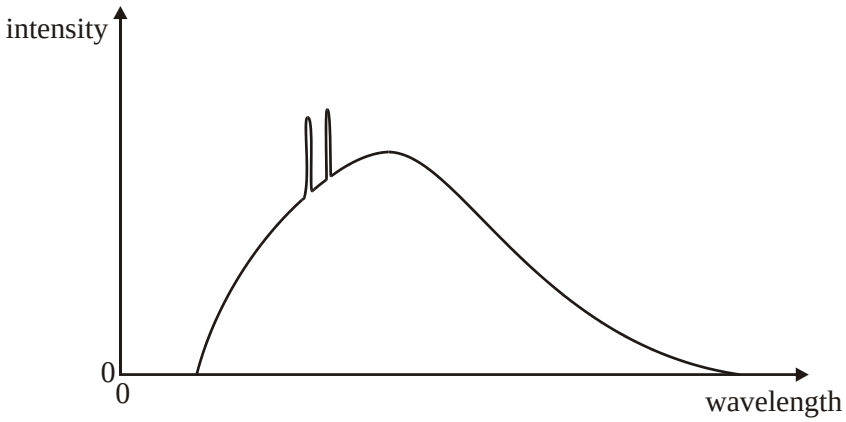
Figure 36.2

How many spectra lines of unique wavelengths corresponding to these energy levels can be observed?

A 4 **B** 9 **C** 10 **D** 20

Ans: C because ${}^{5}_{2}C = 10$

36 The graph below shows a typical X-ray spectrum produced when electrons are accelerated through a potential difference and are then stopped in a metal target.



Which feature of the graph enables this potential difference to be determined?

A The wavelength of the peaks on the graph.
B The maximum wavelength of the X-rays produced.
C The maximum intensity of the X-rays produced.
D The minimum wavelength of the X-rays produced.

Ans: D

X-rays with the shortest wavelength have the highest energy. By conservation of energy, this energy comes from the situation when the electron has a single head-on collision with the target atoms, losing all its energy. With this we can determine the energy that it gains through the potential difference and hence the potential difference.

37 Why is laser light coherent?

A The excited electrons are in a metastable state.
B The system is in a state of population inversion.
C Stimulated emission causes the emitted photon and the incident photon to be of the same phase.
D Photons of the same energy as that of the incident photons are emitted when the electrons transit down from a higher energy level.

Ans: C

The incident and the emitted photon are in phase and of the same frequency. Hence C is the answer.

38 Which statement about semiconductors is correct?

A Their resistivity is normally somewhat greater than that of most metals.
B A “hole” in a semiconductor is due to the removal of a proton.
C Electrical conduction in an n-type semiconductor is due to the transfer of neutrons.
D A p-type semiconductor is produced by doping p-type impurities called donors.

Ans: A.

B is wrong. A hole is due to the removal of an electron from the valence band.
C is wrong. It is due to the transfer of both electrons (in the conduction band) and holes (in the valence band), but with electrons as the majority charge carriers.
D is wrong. It is called acceptors.

39 In the Rutherford scattering experiment, most of the alpha particles passed straight through the gold foil undeflected. Which one of the following is a correct conclusion from this result?

A Most of the mass of the atom is within the atom.
B The diameter of the nucleus is much less than the diameter of the atom.
C The nucleus has a positive charge
D The atom is overall neutral.

Ans: B

40 A Radioactive nucleus X decays by releasing a β-particle. The daughter nucleus is ${}^{111}_{48}Cd$. What is X?

A ${}^{111}_{49}In$
B ${}^{112}_{49}In$
C ${}^{111}_{47}Ag$
D ${}^{111}_{48}Ag$

Ans: C

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