2023-DSE
PHY

PAPER 1A

Methodist College
F.6 First Examination 2022-23

PHYSICS PAPER 1

27th October, 2022.
8.30 am – 11.00 am (2½ hours)

This paper must be answered in English

GENERAL INSTRUCTIONS

(1) There are **TWO** sections, A and B, in this Paper. You are advised to finish Section A in about 50 minutes.

(2) Section A consists of multiple-choice questions in this question paper, while Section B contains conventional questions printed separately in the Question-Answer Book.

(3) Answers to Section A should be marked on the Multiple-choice Answer Sheet while answers to Section B should be written in the spaces provided in the Question-Answer Book. **The Answer Sheet for Section A and the Question-Answer Book for Section B will be collected separately at the end of the examination.**

(4) The diagrams in this paper are **NOT** necessarily drawn to scale.

(5) The last two pages of this question paper contain a list of data, formulae and relationships which you may find useful.

INSTRUCTIONS FOR SECTION A (MULTIPLE-CHOICE QUESTIONS)

(1) Read carefully the instructions on the Answer Sheet. After the announcement of the start of the examination, you should first write down your name, class and number in the spaces provided. No extra time will be given for writing this information after the 'Time is up' announcement.

(2) When told to open this book, you should check that all the questions are there. Look for the words **'END OF SECTION A'** after the last question.

(3) All questions carry equal marks.

(4) **ANSWER ALL QUESTIONS.** You are advised to use an HB pencil to mark all the answers on the Answer Sheet, so that wrong marks can be completely erased with a rubber. You must mark the answers clearly; otherwise you will lose marks if the answers cannot be captured.

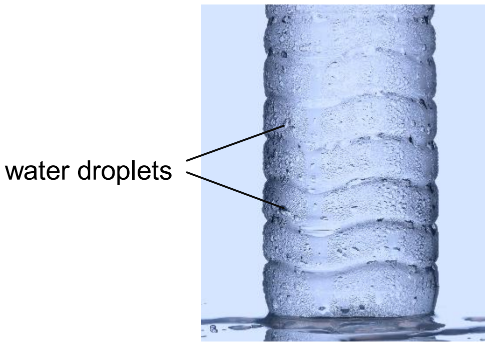
(5) You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.

(6) No marks will be deducted for wrong answers.

Section A

There are 33 questions. Questions marked with * involve knowledge of the extension component.

1 A bottle of water brought out from a refrigerator is left on a table. Water droplets form quickly on the surface of the bottle as shown below. After a while, the surface becomes dry.



Which of the following best explains the above phenomena?

A Water vapour first freezes on the bottle and then melts.

B Water vapour first freezes on the bottle and then evaporates.

C Water vapour first condenses on the bottle and then melts.

D Water vapour first condenses on the bottle and then evaporates.

2 Two objects X and Y of different initial temperatures are placed inside a well-insulated container as shown in Figure (a). They are in good thermal contact. Figure (b) shows the variation of their temperatures with time.

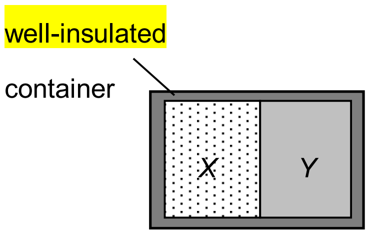


Figure (a)

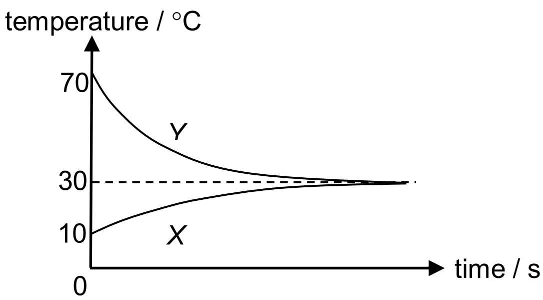


Figure (b)

Which of the following statements is/are correct?

(1) The heat lost by Y is larger than the heat gained by X at the beginning.

(2) X and Y are in thermal equilibrium at 30 °C

(3) The ratio of the heat capacity of X to that of Y is 7:1.

A (2) only

B (1) and (2) only

C (1) and (3) only

D (1), (2) and (3)

3 Ice cubes of total mass 0.05 kg at 0 °C are added to water of mass 0.2 kg at room temperature of 30 °C The final temperature of the mixture is 11 °C. How much energy does the mixture gain from the surroundings?

Given: specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}

specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$

A 2200 J

B 3050 J

C 5350 J

D 6190 J

4 A solid substance X of initial temperature T is insulated from the surroundings. An electric heater of constant power first uses 20 s to raise the temperature of X to 40 °C and then 14 s to raise the temperature from 40 °C to 96 °C. X remains as a solid in the whole process. Find T.

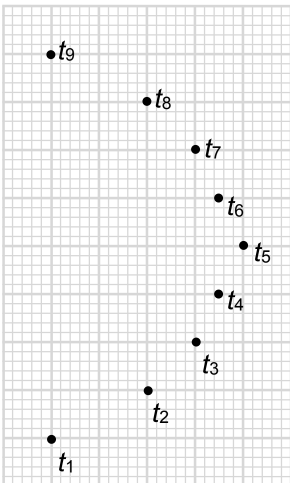
A –40 °C

B –20 °C

C 0 °C

D 20 °C

5 A point object moves continuously. Its position is recorded at equal time interval from time t_1 to t_9 on a grid in scale as shown below.



At time t_5, the object is at the rightmost position. What are the directions of its velocity v and acceleration a at t_5?

	Direction of v	Direction of a
A	↖	↓
B	↑	↓
C	↖	←
D	↑	←

6 A diver jumps upwards and then falls into the swimming pool as shown in Figure (a). She finally stops in the water. The springboard is at height h above the water surface. Figure (b) shows her velocity–time graph in the above process.

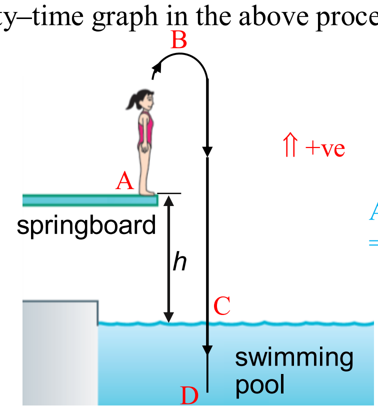


Figure (a)

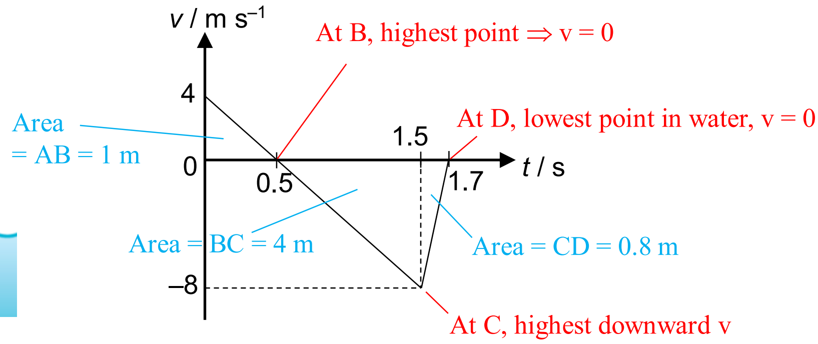


Figure (b)

Find the height h.

h = BC – AB = 3 m

A 1.0 m

B 3.0 m

C 3.8 m

D 4.0 m

7 Two blocks X and Y are placed on a smooth horizontal surface. The masses of X and Y are m and $5m$ respectively. Two horizontal forces F and $2F$ are applied to the blocks as shown. X and Y are in contact when they are moving.

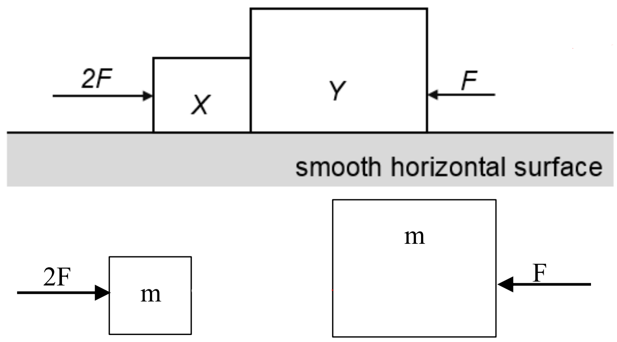
What is the magnitude of the force acting on X by Y?

A $\frac{F}{6}$

B F

C $\frac{11F}{6}$

D $\frac{13F}{6}$



8 The figure below shows two forces F_1 and F_2 acting on a point object O. An additional force F_3 is now added to keep O in equilibrium.

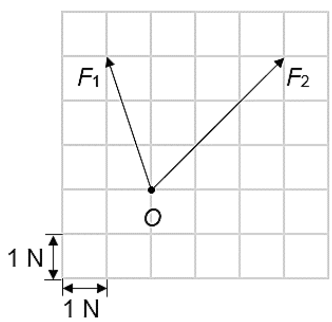
What is the magnitude of F_3?

A 4.0 N

B 5.3 N

C 6.3 N

D 7.4 N



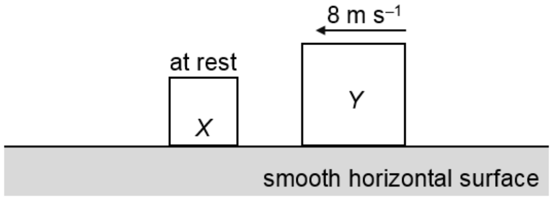
9 On a smooth horizontal surface, block Y of mass 3 kg moves at 8 m s^{-1} and collides head-on with block X of mass 1 kg as shown in the figure. X is initially at rest.

Which of the following is/are the possible speed(s) of Y just after collision?

(1) 2 m s^{-1}

(2) 4 m s^{-1}

(3) 8 m s^{-1}



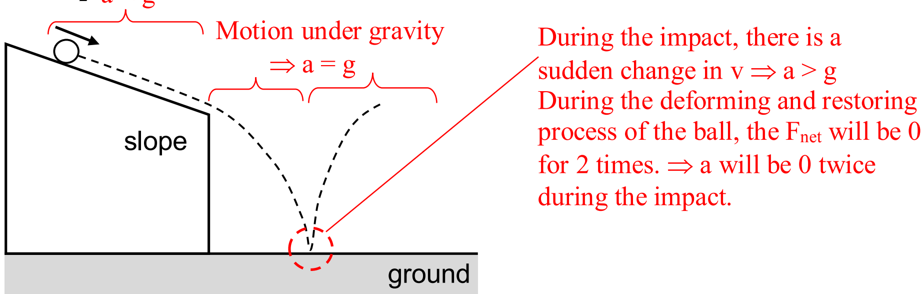
A (1) only

B (2) only

C (1) and (2) only

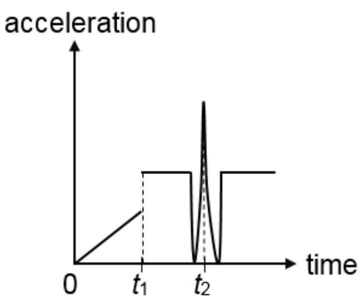
D (2) and (3) only

***10** A ball rolls down a slope from rest as shown. It flies off at the edge of the slope at time t_1 and bounces up after hitting the ground at time t_2. a < g

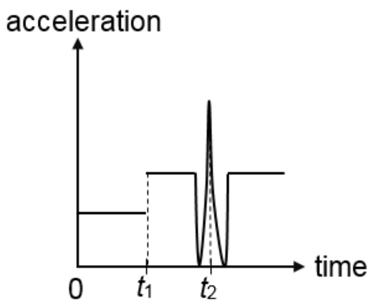


Which of the following graphs best shows how the magnitude of acceleration of the ball changes with time?

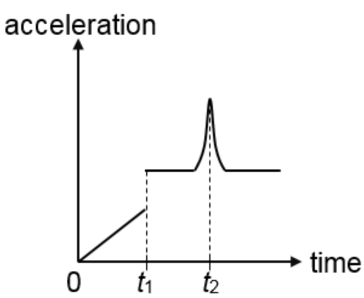
A



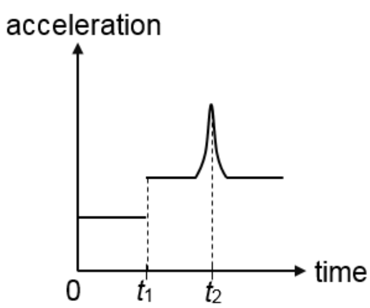
C



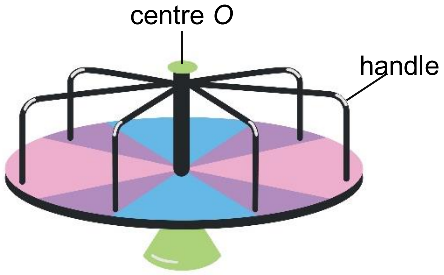
B



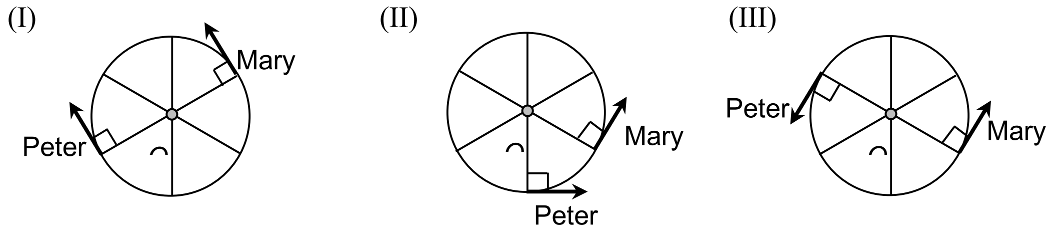
D



11 The roundabout shown below can rotate about its centre *O*. The handles are installed radially from *O* and are equal in length.



Peter and Mary push this roundabout at the end of the handles in the following ways:



If the forces they applied are of equal magnitude, compare the magnitude of the resultant moment about *O* in the above three ways.

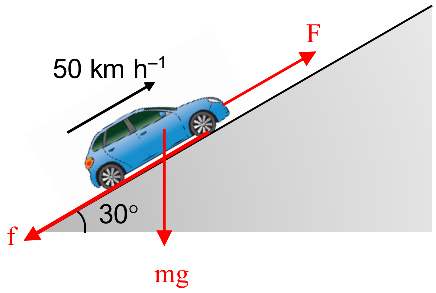
A (I) > (II) > (III)

B (III) > (II) > (I)

C (I) = (II) > (III)

D (II) = (III) > (I)

12 A car of mass 800 kg travels up a ramp steadily at 50 km h^{-1} as shown. The ramp makes an angle of 30° to the horizontal. The total resistive force acting on the car is 1000 N.



Find the power output of the car engine.

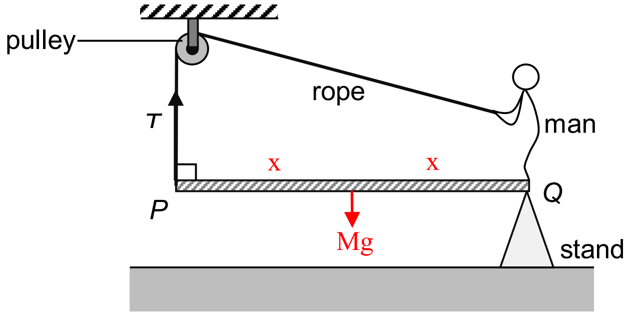
A 13.9 kW

B 68.4 kW

C 108 kW

D 246 kW

13 A man of mass m stands at one end of a uniform plank PQ as shown. The plank has a mass M, with M smaller than m. It is supported by a stand at Q and is hung at P by a light inextensible rope passing a smooth fixed pulley. The man holds the rope tight to keep the plank horizontal.



Which of the following statements about the tension T in the rope are correct? Assume that the plank remains horizontal.

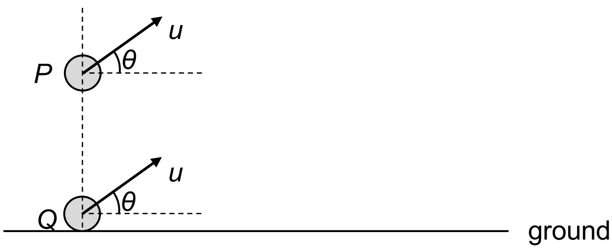
(1) $T = \frac{Mg}{2}$ when the man is at Q.

(2) If the man stands at points other than Q on the plank, T will be larger than that when he is at Q.

(3) $T = mg + \frac{Mg}{2}$ if the man stands at P.

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

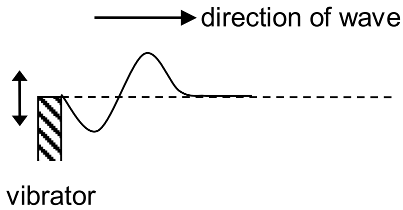
***14** P and Q are two identical balls initially at rest. Q is on the ground and P is right above it as shown. The balls are projected at the same time with the same initial speed u at the same angle θ. They do not bounce when they hit the ground.



Which of the following statements best describes the motion of P and Q?

A P reaches its highest point earlier than Q does.
B The maximum vertical displacement of P is larger than that of Q.
C When P hits the ground, it travels a longer horizontal distance than Q.
D P reaches the ground at a lower speed than Q.

15 A vibrator of frequency 10 Hz generates waves on a string. The figure below shows the shape of the string after the vibrator is switched on for time *t*.



Which of the following correctly shows the value of *t* and the moving direction of the vibrator at this instant?

	Value of *t*	**Moving direction**
A	0.1 s	Upwards
B	0.1 s	Downwards
C	0.25 s	Upwards
D	0.25 s	Downwards

16 A guitar string is plucked and a stationary wave with one loop is formed on the segment between the nut and the saddle. The frequency of the wave is 196 Hz and this produces a note G. The distance between the nut and the saddle is 65 cm. $\Rightarrow \lambda/2 = 0.65$ m $\Rightarrow v = f\lambda = 196(0.65\times 2) = 254.8$ ms^{-1}

Now, a finger presses on the string at a distance *x* from the nut. The string is plucked again to form a stationary wave with one loop between the finger and the saddle. The frequency of the wave is 261.6 Hz and this produces a note C. Assuming that the tension in the string remains unchanged, find *x*.

$\Rightarrow \lambda'/2 = (0.65 - x)$

$\Rightarrow$ v is unchanged

$\Rightarrow \lambda' = (1.3 - 2x)$

$v = f'\lambda' = 261.6(1.3 - 2x) = 254.8$

$\Rightarrow x = 0.163$ m

A 16 cm

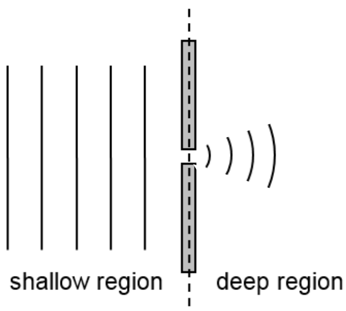
B 22 cm

C 43 cm

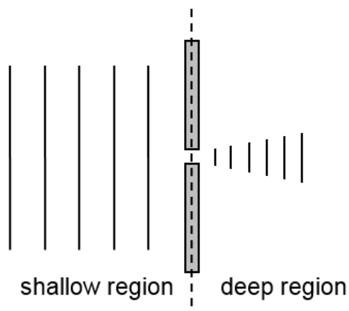
D 49 cm

17 Which of the following correctly show a water wave travelling from a shallow region to a deep region through a narrow slit?

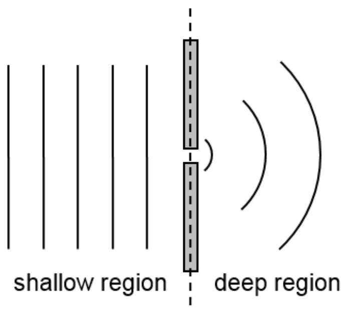
A



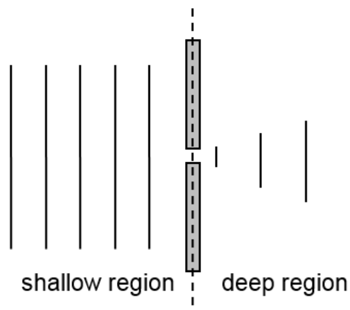
B



C



D



18 Ultrasound is used to measure the thickness of a metal plate. An ultrasound transmitter and receiver is put on the upper surface of the metal plate. It then emits an ultrasound pulse which is reflected by the lower surface and received by the receiver. The time interval between emitting and receiving the pulse is 15 μs. What is the thickness of the metal plate?

Given: speed of sound in metal = 6000 m s^{-1}

A 25 mm

B 40 mm

C 45 mm

D 90 mm

19 Which of the following statements about travelling longitudinal waves are correct?

(1) All particles are vibrating in a direction parallel to the direction of travel of the wave.

Displacement = 0 but at highest speed.

(2) A particle at the centre of a compression or rarefaction is momentarily at rest.

(3) Particles within one wavelength are vibrating similarly but with slight differences in time.

A (1) and (2) only

B (1) and (3) only

C (2) and (3) only

D (1), (2) and (3)

***20** A concave lens has a focal length of 20 cm. If the distance *u* between an object and the lens is twice the distance *v* between its image and the lens, find *v*.

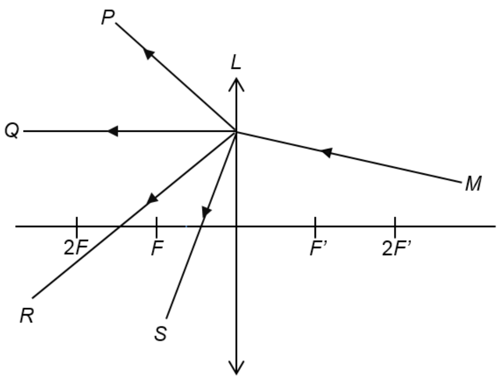
A 10 cm

B 20 cm

C 30 cm

D 60 cm

21 A light ray *M* travels towards a convex lens *L* as shown in the following figure. *F* indicates a focal point of the lens.



Which of the following is a possible refracted ray of *M*?

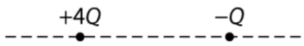
A ray *P*

B ray *Q*

C ray *R*

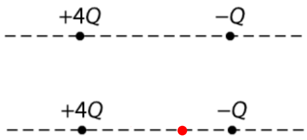
D ray *S*

22 Point charges +4Q and –Q are fixed on a straight line as shown.



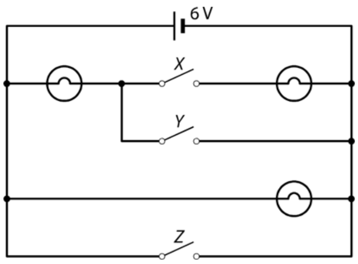
A positive test charge +q is placed at a certain position on the straight line joining the two charges. At that position, the electric fields due to the two charges are equal in magnitude. If the test charge is released, which of the following subsequent motions of the test charge is/are possible?

(1) Remaining at rest
(2) Moving to the left
(3) Moving to the right



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

23 A 6 V battery is connected to three identical light bulbs of rating '6 V, 3 W' and three switches X, Y and Z as shown.



Which of the following combinations result in working of two light bulbs at their rated values?

	X	***Y***	***Z***
(1)	open	closed	open
(2)	closed	open	closed
(3)	closed	closed	open

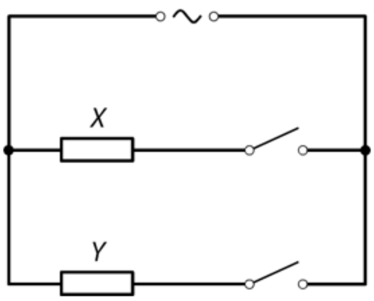
A (1) and (2) only
B (1) and (3) only
C (2) and (3) only
D (1), (2) and (3)

24 When a 3 V battery, an ammeter and a 6 Ω resistor are connected in series, the ammeter reading is 0.4 A. What is the reading of the ammeter if the 6 Ω resistor is replaced by a 3 Ω resistor?

A 0.67 A
B 0.8 A
C 1 A
D 2 A

25 A water heater consists of two heating elements X and Y. A simplified diagram of the circuit is shown below.

If only X is used, it takes time t_1 to boil 2 kg of water. If only Y is used, it takes time t_2 to boil the same amount of water. Now, if both X and Y are used, how long will it take to boil the same amount of water?



A $t_1 + t_2$

B $\frac{1}{2} \cdot (t_1 + t_2)$

C $\frac{t_1 t_2}{t_1 + t_2}$

D $\frac{1}{\sqrt{2}} \cdot \frac{t_1 t_2}{t_1 + t_2}$

26 An electric iron is connected to a socket by a power cable. The cable has three wires X, Y and Z inside it. When the electric iron is working normally, it is found that

- a voltmeter connected across wires Y and Z gives zero reading, and
- no current passes through wire Y.

Which of the following statements are correct?

(1) The fuse should be fitted to wire X.

(2) Wire Y is connected to the metal casing of the iron.

(3) The iron can still operate when wire Z is broken accidentally.

A (1) and (2) only

B (1) and (3) only

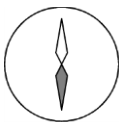
C (2) and (3) only

D (1), (2) and (3)

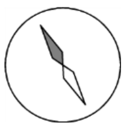
27 When a compass is placed between a pair of magnets, its needle points in the direction as shown.

Which of the following could be the orientation of the needle when the magnets are removed?

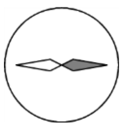
A



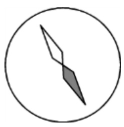
B



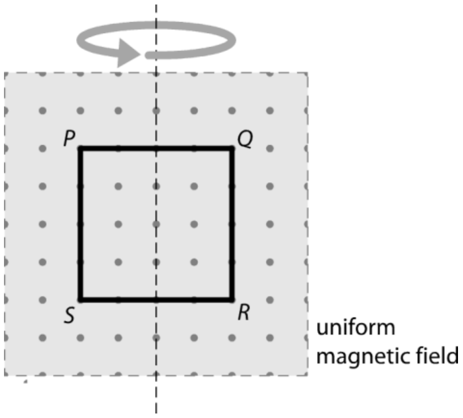
C



D



28 A square metal loop *PQRS* in a uniform magnetic field is being rotated steadily about the axis as shown below. At the instant shown, the loop is in the plane of the paper.



Which of the following statements about the metal loop is correct?

A The current induced in the loop flows clockwise at the instant shown.

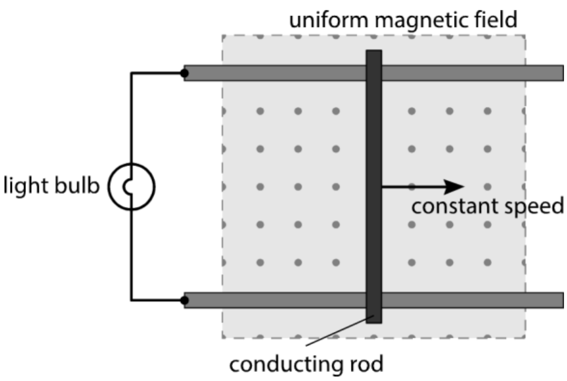
PS & QR are moving // to B ∴ no induced current & emf at that instant

B The induced e.m.f. in the loop attains its maximum value at the instant shown.

C The torques produced by the magnetic forces acting on sides *PS* and *QR* oppose the rotation of the loop.

D The current induced in the loop is a DC current.

***29** A conducting rod is placed perpendicularly on a pair of rails inside a uniform magnetic field pointing out of the paper. A light bulb is connected across the rails with conducting wires.

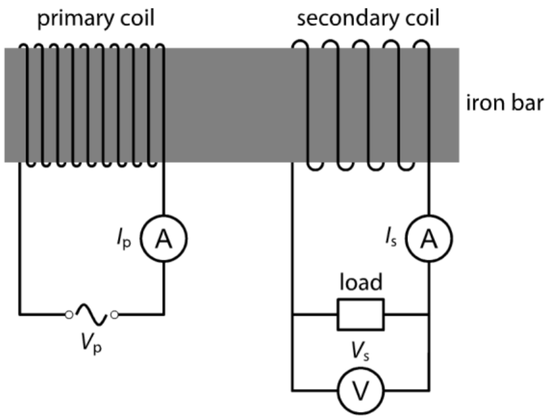


The light bulb glows when the rod moves at a constant speed in the direction shown. Which of the following actions can increase the brightness of the light bulb?

(1) Increasing the speed of the rod
(2) Increasing the magnitude of the magnetic field
(3) Decreasing the separation between the two rails

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

***30** Peggy constructs a simple transformer as shown and records the values of the primary voltage V_p, the primary current I_p, the secondary voltage V_s and the secondary current I_s.



To her surprise, she finds that $\frac{V_p}{V_s} \neq \frac{N_p}{N_s}$. Which of the following is a possible cause?

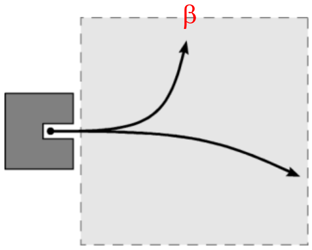
A The resistance of the load is too high.

B A lot of magnetic flux escapes from the coils.

C Strong eddy currents are induced in the iron bar.

D A lot of heat is generated when the iron bar is magnetized and demagnetized.

31 A beam of α and β particles enters a uniform field. The following figure shows how the two kinds of particles are deflected inside the field.



side view

Which of the following fields can deflect the α and β particles in such a way?

(1) An electric field pointing upwards

(2) An electric field pointing downwards

(3) A magnetic field pointing out of the paper

(4) A magnetic field pointing into the paper

A (1) and (3) only

B (1) and (4) only

C (2) and (3) only

D (2) and (4) only

32 Which of the following statements about α particles and γ rays is **INCORRECT**?

A The ionizing power of α particles is stronger than that of γ rays.

B The penetrating power of α particles is weaker than that of γ rays.

C The speed of γ rays in a vacuum is higher than that of α particles.

D γ rays can blacken photographic films but α particles cannot (in a dark room).

33 The following shows a nuclear reaction.

$$^{14}_{7}N + ^{1}_{0}n \rightarrow ^{14}_{6}C + ^{1}_{1}p$$

Which of the following statements about the nuclear reaction is/are correct?

(1) The reaction is a nuclear fission.

(2) The reaction is spontaneous.

(3) The reaction can trigger a chain reaction.

A (1) only

B (2) only

C (1) and (3) only

D (2) and (3) only

End of Section A

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
acceleration due to gravity	$g = 9.81\ \text{m s}^{-2}$ (close to the Earth)
universal gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
speed of light in vacuum	$c = 3.00 \times 10^8\ \text{m s}^{-1}$
charge of electron	$e = 1.60 \times 10^{-19}\ \text{C}$
electron rest mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
atomic mass unit	$\text{u} = 1.661 \times 10^{-27}\ \text{kg}$ (1 u is equivalent to 931 MeV)
astronomical unit	$\text{AU} = 1.50 \times 10^{11}\ \text{m}$
light year	$\text{ly} = 9.46 \times 10^{15}\ \text{m}$
parsec	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206265\ \text{AU}$
Stefan constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}^{-1}$

Rectilinear motion

For uniformly accelerated motion:

$$v = u + at$$

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

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

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \frac{4}{3}\pi r^3$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ (in radians)

Astronomy and Space Science

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma AT^4$	Stefan's Law
$\left\lvert\frac{\Delta f}{f_0}\right\rvert \approx \frac{v}{c} \approx \left\lvert\frac{\Delta\lambda}{\lambda}\right\rvert$	Doppler effect

Energy and Use of Energy

$E = \frac{\Phi}{A}$	illuminance
$\frac{Q}{t} = k\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \frac{k}{d}$	thermal transmittance U-value
$P = \frac{1}{2}\rho Av^3$	maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e{v_{max}}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\epsilon_0^2}\right\} = -\frac{13.6}{n^2}\text{eV}$	energy level equation for hydrogen atom
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)

Medical Physics

$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$\text{power} = \frac{1}{f}$	power of a lens
$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

A1.	$E = mc\,\Delta T$	energy transfer during heating and cooling
A2.	$E = \ell \Delta m$	energy transfer during change of state
A3.	$pV = nRT$	equation of state for an ideal gas
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	kinetic theory equation
A5.	$E_K = \frac{3RT}{2N_A}$	molecular kinetic energy
B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	force
B2	moment $= F \times d$	moment of a force
B3.	$E_P = mgh$	gravitational potential energy
B4.	$E_K = \frac{1}{2}mv^2$	kinetic energy
B5.	$P = Fv = \frac{W}{t}$	mechanical power
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration
B7.	$F = \frac{Gm_1 m_2}{r^2}$	Newton's law of gravitation
C1.	$\Delta y = \frac{\lambda D}{a}$	fringe width in double-slit interference
C2.	$d \sin\theta = n\lambda$	diffraction grating equation
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens

D1.	$F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$	Coulomb's law
D2.	$E = \frac{Q}{4\pi\epsilon_0 r^2}$	electric field strength due to a point charge
D3.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
D4.	$R = \frac{\rho l}{A}$	resistance and resistivity
D5.	$R = R_1 + R_2$	resistors in series
D6.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
D7.	$P = IV = I^2 R$	power in a circuit
D8.	$F = BQv \sin\theta$	force on a moving charge in a magnetic field
D9.	$F = BIl \sin\theta$	force on a current-carrying conductor in a magnetic field
D10.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
D11.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
D12.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
D13.	$\frac{V_S}{V_P} \approx \frac{N_S}{N_P}$	ratio of secondary voltage to primary voltage in a transformer
E1.	$N = N_0 e^{-kt}$	law of radioactive decay
E2.	$t_{1/2} = \frac{\ln 2}{k}$	half-life and decay constant
E3.	$A = kN$	activity and the number of undecayed nuclei
E4.	$E = mc^2$	mass–energy relationship