福建中學

FUKIEN SECONDARY SCHOOL

S6 Mock Examination (2020-2021)

Physics Paper 1

(2 hours 30 minutes)

Section A: Multiple-Choice Questions

Date: 22nd January 2021 Name: _____

Time: 8:30a.m. – 11:00a.m. Class: _____ No.: _____

Instructions to students:

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 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 on Question-Answer Book. **The Answer Sheet for Section A and the Question-Answer Book for Section B must be handed in 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.

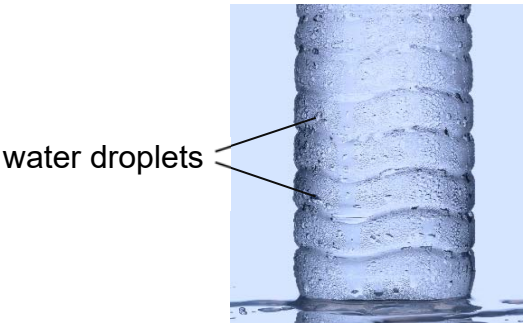
INSTRUCTIONS FOR SECTION A (MULTIPLE-CHOICE QUESTIONS)

1. Read the instructions on the Answer Sheet carefully. Insert the information required in the spaces provided.
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 should use an **HB** pencil to mark all your answers on the Answer Sheet. Wrong marks must be completely erased.
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 taken 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.

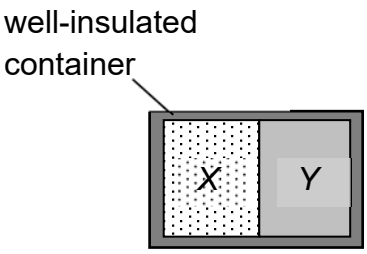


Figure (a)

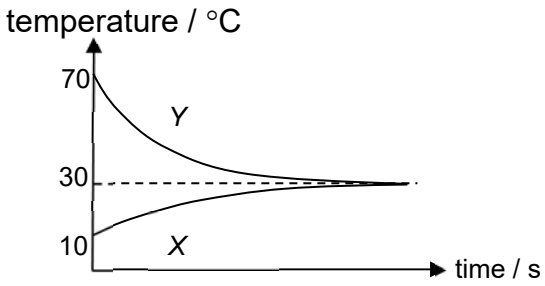


Figure (b)

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.

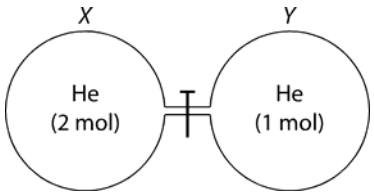
A. (2) only

B. (1) and (2) only

C. (1) and (3) only

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

*3. Two identical vessels *X* and *Y* are connected by a small tube of negligible volume with a tap. Initially, the tap is closed and both vessels are at the same temperature. Vessel *X* contains 2 moles of helium (He) while vessel *Y* contains 1 mole of helium. The pressure of the helium in vessel *X* is *P*.



After the tap is opened, the helium slowly reaches a new steady state. Find the pressure of the helium in the two vessels in terms of *P* if the temperature remains unchanged.

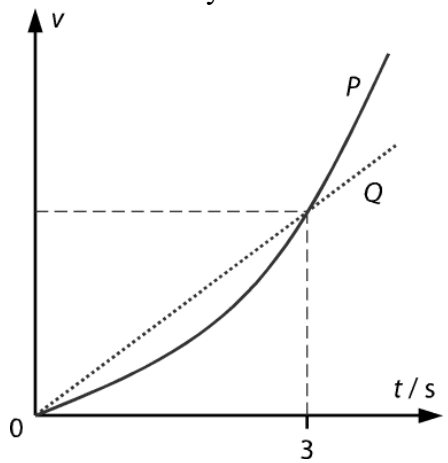
A. $\frac{1}{2}P$

B. $\frac{2}{3}P$

C. $\frac{3}{4}P$

D. $\frac{4}{5}P$

4. Two cars *P* and *Q* travel on a straight road with the same starting position. The velocity–time graph below shows how they move.



Which of the following statements is/are correct?

(1) The cars have the same instantaenous velocity at $t = 3$ s.

(2) The cars have the same average velocity from $t = 0$ to 3 s.

(3) *P* overtakes *Q* at $t = 3$ s.

A. (1) only

B. (3) only

C. (1) and (2) only

D. (2) and (3) only

5. Ball X is thrown vertically upwards with an initial velocity of 10 m s^{-1} from the ground at $t = 0$. Ball Y is thrown vertically upwards with the same initial velocity from the same position at $t = 0.5$ s. When will the two balls meet in air?

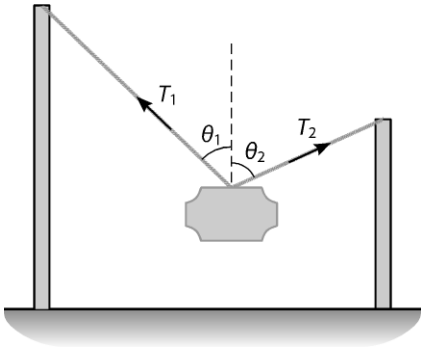
   A. At $t = 0.77$ s

   B. At $t = 1.02$ s

   C. At $t = 1.27$ s

   D. At $t = 1.52$ s

6. A sign is hung by two ropes as shown below. The tension in the longer rope is T_1 and that in the shorter rope is T_2. They make angles of θ_1 and θ_2 with the vertical respectively. Neglect the weight of the ropes. Find $T_1 : T_2$.



   A. 1 : 1

   B. $\cos \theta_2 : \cos \theta_1$

   C. $\sin \theta_2 : \sin \theta_1$

   D. Cannot be determined. $T_1 : T_2$ depends on how long the ropes are.

7. A jet fighter flies vertically upwards with an acceleration of 60 m s^{-2}. What is the force exerted on the pilot of mass 75 kg by the chair?

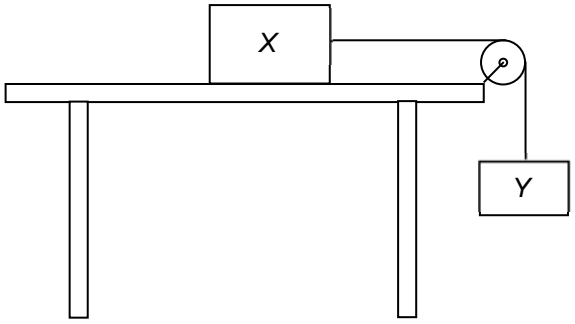
   A. 736 N

   B. 3764 N

   C. 4500 N

   D. 5236 N

8. Block *X* is initially at rest on a rough table. Block *Y* is connected to block *X* by an inextensible string over a pulley as shown below. The masses of blocks *X* and *Y* are 3 kg and 2 kg respectively.



Block *Y* is then released and block *X* starts to move towards the right. The friction acting on block *X* is 4 N. What is the total kinetic energy of the system after block *X* has moved by 50 cm?

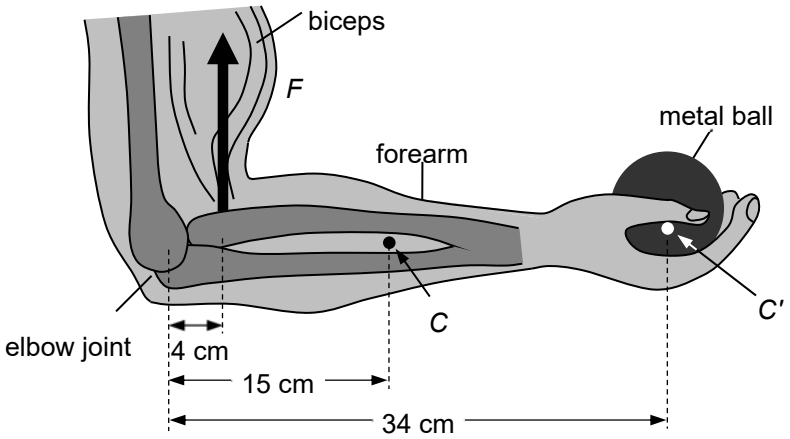
A. 7.81 J

B. 9.81 J

C. 11.8 J

D. 12.7 J

9. The figure below shows a human arm. The forearm and the hand have a total mass of 1.5 kg and their centre of gravity *C* is 15 cm from the elbow joint.



Suppose the hand holds a metal ball of mass 5 kg. The centre of gravity *C'* of the metal ball is 34 cm from the elbow joint. A force *F* applied by the biceps 4 cm from the elbow joint holds the forearm at right angles to the arm. Find the magnitude of *F*.

A. 362 N

B. 408 N

C. 472 N

D. 553 N

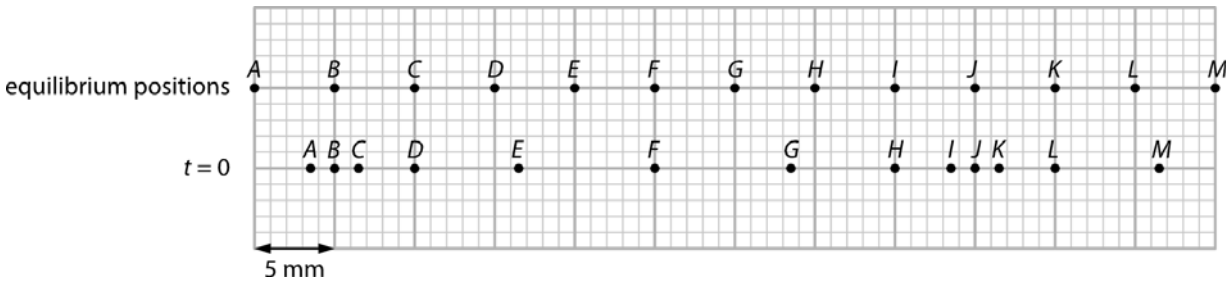
10. Two identical balls *P* and *Q* each hit a stationary target with the same initial speed elastically. After the collision, *P* stops (call it case 1) while *Q* moves backwards (call it case 2). In which case the target has the larger magnitudes of momentum and kinetic energy after collision?

	Momentum	**Kinetic energy**
A.	case 1	case 1
B.	case 1	case 2
C.	case 2	case 1
D.	case 2	case 2

*11. A spacecraft is launched into space from the Earth's surface. Which of the following best describes the distance *d* of the spacecraft from the Earth's surface when the Earth's gravitational force experienced by the spacecraft is half of that on the Earth's surface? Let *R* be the radius of the Earth.

A. $d < 0.5R$
B. $0.5R < d < R$
C. $d = R$
D. $R < d < 1.5R$

12. A train of longitudinal wave travels through a medium. The figure below shows the positions of particles *A* to *M* at time $t = 0$. At the moment shown, particle *D* is momentarily at rest and particle *G* is moving towards the right.



Which of the following statements is correct?

A. The wavelength of the wave is 20 mm.
B. The wave is travelling from right to left.
C. Particle *C* is moving towards the right at $t = 0$.
D. Particle *J* is momentarily at rest at $t = 0$.

13. A train of water waves is produced in a ripple tank. The frequency of the dipper of the ripple tank is 8 Hz. The separation of two adjacent wavefronts is 2 cm. Which of the following statements is/are correct?

(1) A water particle takes 0.0625 s to move from the crest to the trough of the wave.

(2) The water particles move at a speed of 16 cm s^{-1}.

(3) The amplitude of the water wave depends on the frequency of the dipper.

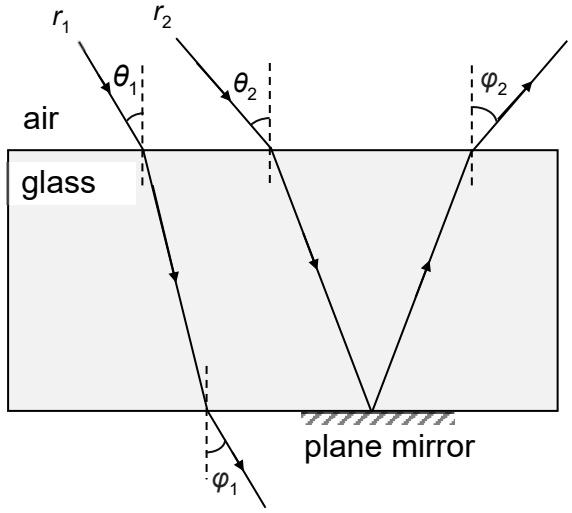
A. (1) only

B. (2) only

C. (1) and (2) only

D. (2) and (3) only

14. Two light rays r_1 and r_2 enter a rectangular glass block from air at angles θ_1 and θ_2 respectively. r_1 leaves the glass block at an angle φ_1, while r_2 is reflected by a plane mirror and leaves the block at an angle φ_2 as shown below. Given that $\theta_1 < \theta_2$.



Which of the following relationships between φ_1 and φ_2 is correct?

A. $\varphi_1 < \varphi_2$

B. $\varphi_1 = \varphi_2$

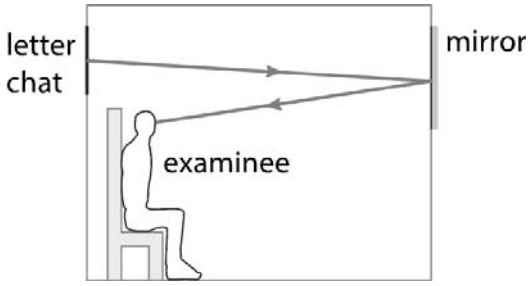
C. $\varphi_1 > \varphi_2$

D. It cannot be determined because the refractive index of glass is not known.

15. The figure below shows a letter chart which is used for eye examination.

p o x b

The letter chart is posted on the wall of an examination room. The examinee is required to look at the letter chart through a mirror as shown below.



What can the examinee see through the mirror?

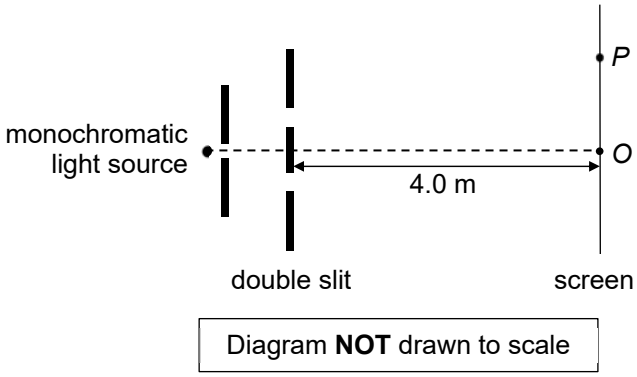
A. b o x p

B. q o x d

C. q x o d

D. d x o q

*16. In the Young's double slit experiment as shown below, a double slit is placed 4.0 m away from a screen. The slit separation is 0.5 mm. When a monochromatic light of wavelength 520 nm is used, the central bright fringe is observed at *O*, while the 9th bright fringe is observed at *P*.



Which of the following changes will still give a bright fringe at *P*?

(1) Moving the screen away from the slit by 0.5 m.

(2) Using monochromatic light of wavelength 624 nm instead of 520 nm.

(3) Moving the light source away from the double slit by 5 mm.

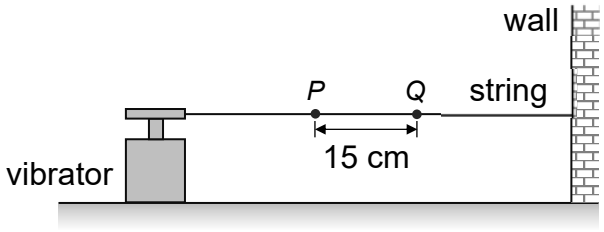
A. (2) only

B. (1) and (3) only

C. (2) and (3) only

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

17. A string is fixed to a wall at one end and tied to a vibrator at the other end as shown below. *P* and *Q* are two particles on the string separated by 15 cm. The vibrator generates a stationary wave of wavelength 10 cm on the string.



If neither *P* nor *Q* is stationary, which of the following statements about the two particles must be correct?

(1) *P* and *Q* vibrate in antiphase.

(2) *P* and *Q* vibrate with the same amplitude.

(3) *P* and *Q* reach their equilibrium positions at the same time.

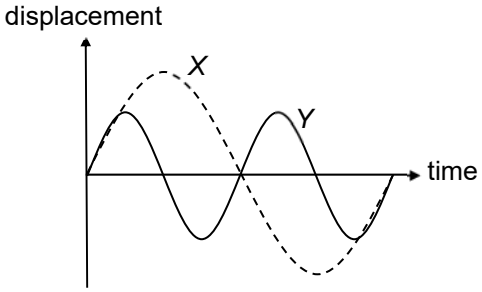
A. (1) and (2) only

B. (1) and (3) only

C. (2) and (3) only

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

18. A detector placed at point *O* detects two musical notes *X* and *Y*. The waveforms of the two notes displayed on the detector are shown below.



Which of the following statements about notes *X* and *Y* is INCORRECT?

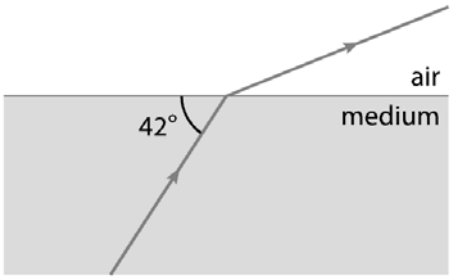
A. At *O*, *X* is louder than *Y*.

B. The quality of *X* is the same as that of *Y*.

C. The pitch of *X* is lower than that of *Y*.

D. The speed of *X* is lower than that of *Y* in air.

19. A light ray travels from a medium to air as shown below.



Which of the following values of the refractive index of the medium is/are possible?

(1) 1.3 (2) 1.4 (3) 1.5

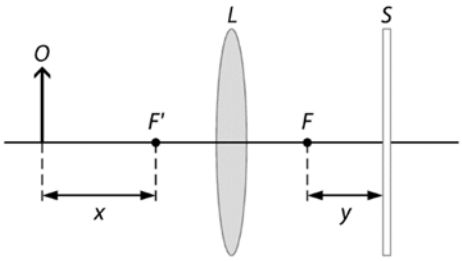
A. (1) only

B. (3) only

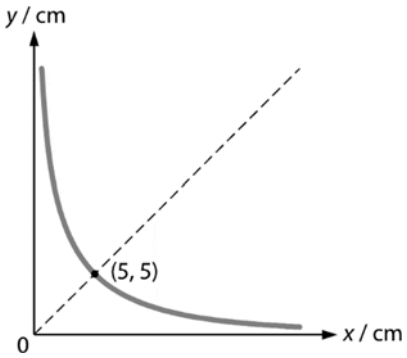
C. (1) and (2) only

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

*20. Karen uses an object *O* and a screen *S* to investigate the focal length of a convex lens *L*. She adjusts the positions of the object and the screen until a sharp image is formed on the screen. Then she measures the distance *x* of the object from the principal focus *F'*, and the distance *y* of the screen from the principal focus *F*, as shown below.



The graph of *y* against *x* that she obtained is shown below. Find the focal length of the lens.



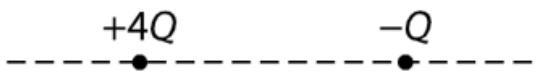
A. 2.5 cm

B. 5 cm

C. 10 cm

D. 20 cm

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

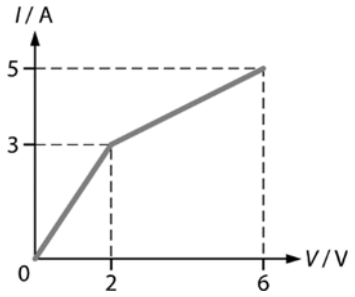


A positive test charge +q is placed at a certain position on the straight line joining the two charges. At that position, the electric fields due to the two charges are equal in magnitude. If the test charge is released, which of the following subsequent motions of the test charge is/are possible?

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

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

22. The graph below shows the I–V characteristic curve of a conductor.

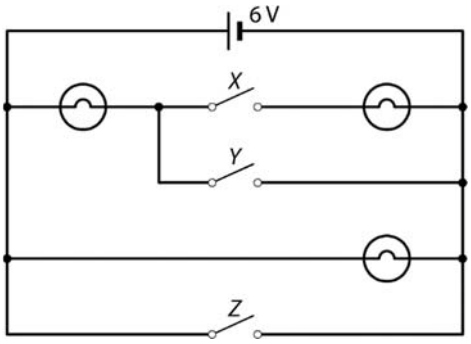


Which of the following statements is/are correct?

(1) The conductor is an ohmic conductor when the voltage across it is less than 2 V.
(2) The resistance of the conductor is 1.5 Ω when the voltage across it is 1 V.
(3) The resistance of the conductor is 1.2 Ω when the voltage across it is 4 V.

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

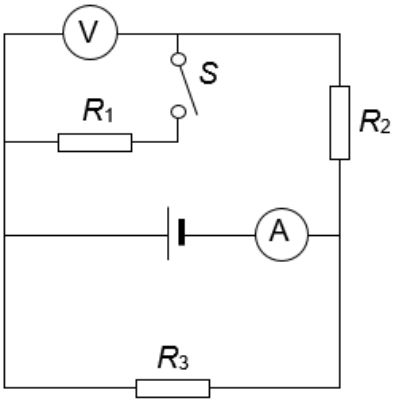
23. A 6 V battery is connected to three identical light bulbs of rating '6 V, 3 W' and three switches *X*, *Y* and *Z* as shown below. Which of the following combinations result in working of two light bulbs at their rated values?



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

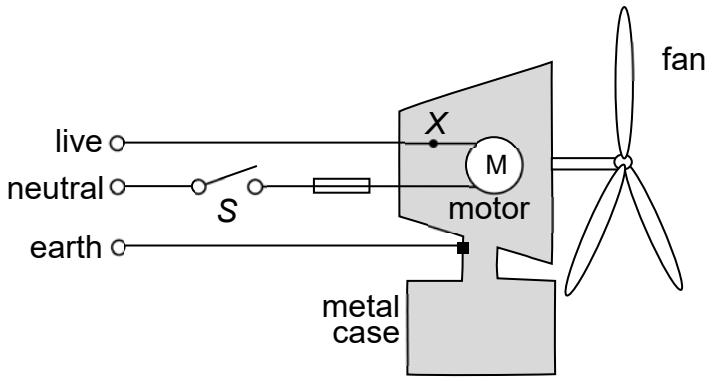
A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

24. In the circuit shown below, the cell has negligible internal resistance. The ammeter and voltmeter are ideal. When the switch *S* is closed, how do the readings of the ammeter and the voltmeter change?



	Reading of ammeter	**Reading of voltmeter**
A.	increase	increase
B.	increase	decrease
C.	decrease	increase
D.	decrease	decrease

25. The figure below shows the simplified structure of an electric fan. The earth wire is connected to the metal case of the fan. Some of the circuit components are wired incorrectly.



Which of the following will happen when point *X* on the wire touches the metal case and forms a short circuit?

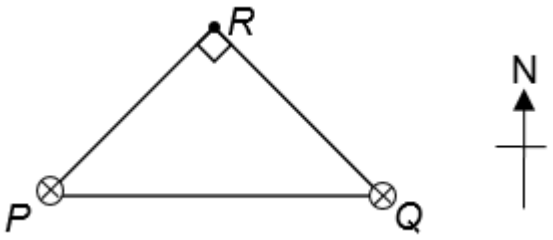
A. The motor will be overheated by a large current.

B. The fuse will not blow even if *S* is closed.

C. The electric fan will operate at a power higher than the rated value.

D. If someone touches the metal case, the person will get an electric shock.

26. Two long straight parallel wires *P* and *Q* carry currents of equal magnitude directed into the page. The wires are put at the vertices of a right-angled isosceles triangle as shown below.



Which direction does the resultant magnetic field at *R* point to?

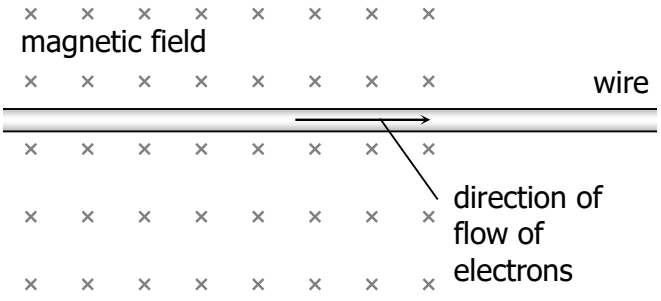
A. East

B. South

C. West

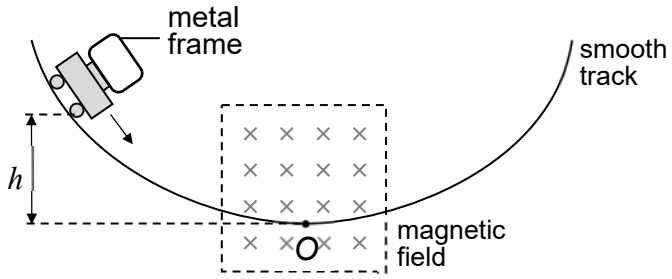
D. North

27. A straight wire is placed in a uniform magnetic field and the electrons flow along the wire in the direction as shown below. What is the direction of magnetic force acting on the wire?



A. Into the paper
B. Out of the paper
C. Upward
D. Downward

28. A small metal frame is attached on a plastic trolley as shown below. The trolley is released from a height *h* above the lowest point *O* of the smooth track. The trolley then slides along the track and passes through a square region of uniform magnetic field. The whole metal frame is inside the magnetic field when the trolley reaches *O*.



Assume air resistance acting on the trolley is negligible. Which of the following statements correctly describe(s) the motion of the trolley?

(1) The trolley experiences the largest opposing force when it reaches *O*.
(2) The trolley reaches a maximum height smaller than *h* on the other side of the track.
(3) If the magnetic field points out of the page, the direction of magnetic force experienced by the trolley when it enters the field will reverse.

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

*29. In Figure (a), an axial search coil is placed inside a solenoid. The plane of the coil is perpendicular to the handle. The coil is connected to a voltmeter which measures the voltage V across the coil. Figure (b) shows how the current I in the solenoid varies with time t.

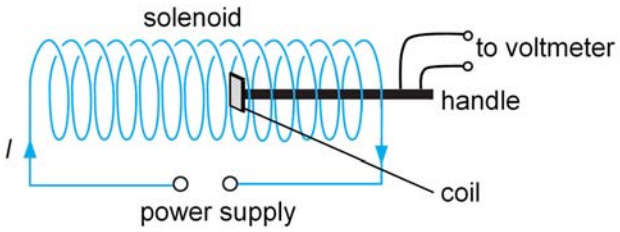


Figure (a)

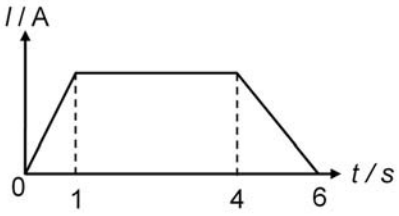
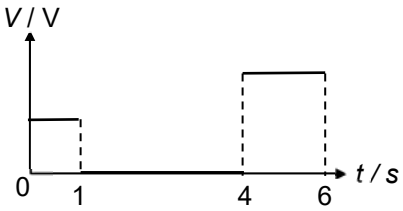


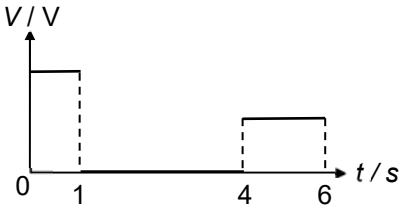
Figure (b)

Which of the following graphs best represents how V varies with t?

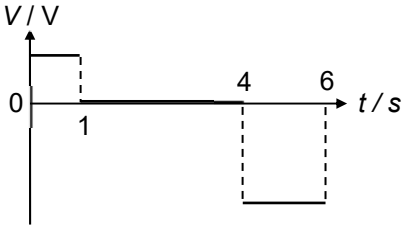
A.



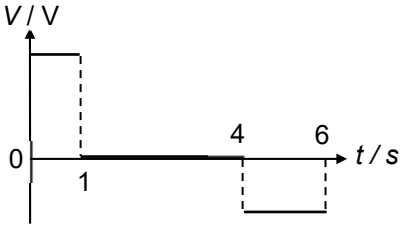
B.



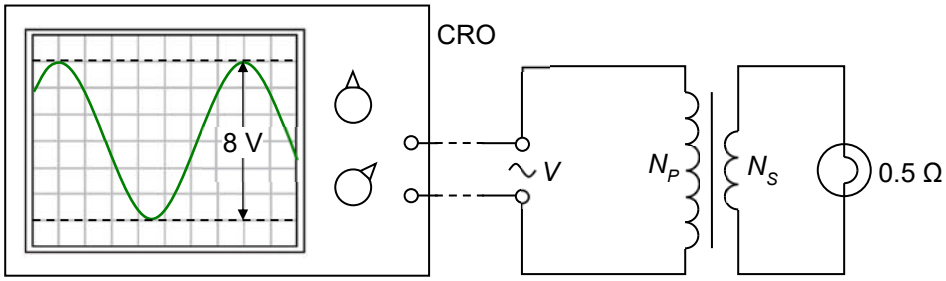
C.



D.



*30. A light bulb of resistance 0.5 Ω is connected to an a.c. power supply via a transformer as shown below. The transformer is ideal and its turns ratio $N_P : N_S$ is 2 : 1. The output voltage V of the a.c. power supply is measured by a CRO.

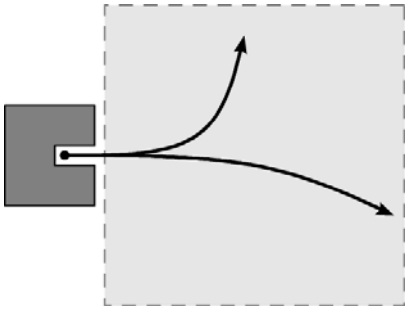


The CRO shows that the peak-to-peak value of V is 8 V. Find the average power dissipated by the light bulb.

A. 4 W
B. 8 W
C. 16 W
D. 64 W

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

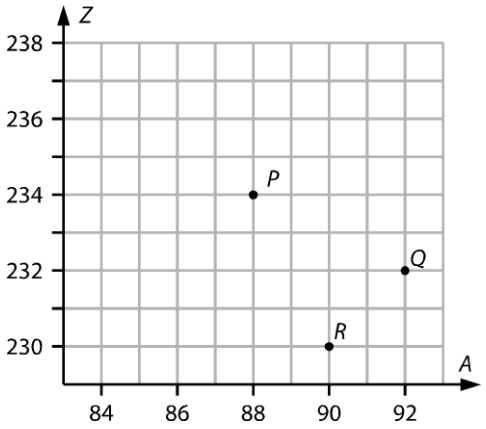
side view



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

	Electric field	**Magnetic field**
A.	pointing upwards	pointing out of the paper
B.	pointing upwards	pointing into the paper
C.	pointing downwards	pointing out of the paper
D.	pointing downwards	pointing into the paper

32. A $^{238}_{92}U$ nuclide undergoes several α and β decays before it changes to another stable nuclide. The A–Z (mass number–atomic number) graph below shows three nuclides P, Q and R.



How many of the above nuclides can be produced during the decay series of a U-238 nuclide?

A. 0

B. 1

C. 2

D. 3

33. Which of the following quantities of a radioactive sample would decrease exponentially with time?

(1) the probability that a nucleus decays in a unit time

(2) the number of undecayed nuclei

(3) the natural logarithm of the rate of decay

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	$R = 8.31$ J mol^{-1} K^{-1}
Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
acceleration due to gravity	$g = 9.81$ m s^{-2} (close to the Earth)
universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
speed of light in vacuum	$c = 3.00 \times 10^8$ m s^{-1}
charge of electron	$e = 1.60 \times 10^{-19}$ C
electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
atomic mass unit	u $= 1.661 \times 10^{-27}$ kg (1 u is equivalent to 931 MeV)
astronomical unit	AU $= 1.50 \times 10^{11}$ m
light year	ly $= 9.46 \times 10^{15}$ m
parsec	pc $= 3.09 \times 10^{16}$ m $= 3.26$ ly $= 206\,265$ AU
Stefan constant	$\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}
Planck constant	$h = 6.63 \times 10^{-34}$ J s

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

$\left|\frac{\Delta f}{f_0}\right| \approx \frac{v}{c} \approx \left|\frac{\Delta\lambda}{\lambda_0}\right|$ 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

$P = \frac{1}{2}\rho A v^3$ maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e v_{max}{}^2 = hf - \phi$ Einstein's photoelectric equation

$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0{}^2}\right\} = -\frac{13.6}{n^2}$ 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.	$E = l\Delta m$	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.	$P = Fv$	mechanical power
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration
B7.	$F = \frac{Gm_1m_2}{r^2}$	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.	$F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	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.	$P = IV = I^2R$	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.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	half-life and decay constant
E3.	$A = kN$	activity and the number of undecayed nuclei
E4.	$\Delta E = \Delta mc^2$	mass-energy relationship