2022-DSE
PHY

PAPER 1A

DIOCESAN BOYS' SCHOOL

HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2022

G 12 FINAL EXAMINATION

PHYSICS PAPER 1

Time allowed: 2 ½ hours

This paper must be answered in English

Name: _____ Class: _____ ( )

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 Question-Answer Book B.

(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.

(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.

1. Michael pours some hot water at 70 °C into a glass at room temperature (25 °C) . Assuming heat loss to the surroundings in this process is **NOT** negligible, which of the following statements are **incorrect**?

   (1) The energy gained by the glass is equal to the energy lost by the hot water.
   (2) The average kinetic energy of the molecules in the water decreases.
   (3) At a time long after the water is poured into the glass, the temperature of the water and glass is greater than 25 °C .

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

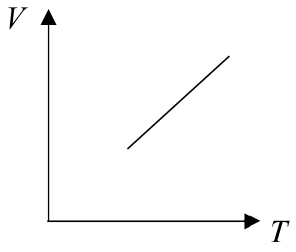
2. When an immersion heater is immersed into a beaker of water initially at 25 °C, it takes 2 minutes for it to start boiling. How much longer does it take for the same heater to boil all water completely?
   Given: specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$
   specific latent heat of vaporization of water = 2.26×10^6 J kg^{-1}

   A. 10 minutes
   B. 14 minutes
   C. 18 minutes
   D. Cannot be determined as the mass of water is not given.

3. The pressure of an ideal gas of n moles and N molecules is kept constant at P. The graph below shows the variation of its volume V and absolute temperature T .

   Which of the expressions correctly represents the slope of the graph?
   (R is the universal gas constant and N_A is the Avogadro constant.)

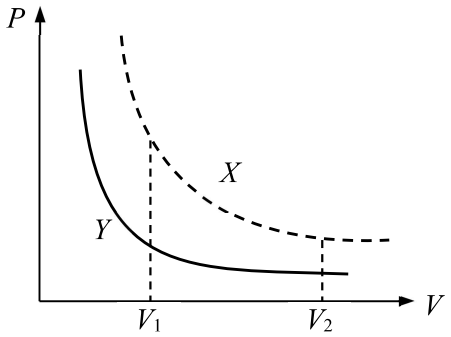
   A. $\frac{P}{NR}$
   B. $\frac{NR}{P}$
   C. $\frac{nR}{N_A P}$
   D. $\frac{NR}{N_A P}$



4. A helium gas is at temperature 27 °C . Find the root-mean-square speed of the gas molecules. (Given: mass of a helium atom = 6.65×10^{-27} kg)

   A. 410 m s^{-1}
   B. 970 m s^{-1}
   C. 1370 m s^{-1}
   D. Cannot be determined as the pressure of the gas is not given.

5. *X* and *Y* are ideal gases of the same type and have the same total mass. They both undergo expansion from volume V_1 to V_2 under two constant temperatures. The pressures, *P*, of the two gases against their volumes, *V*, are shown in the graph below.

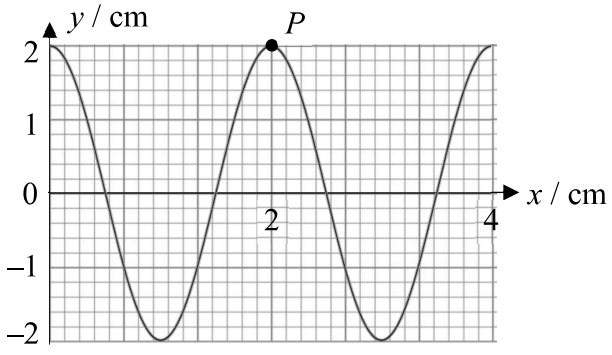


   Which of the following statements is/are correct?

   (1) *X* has a higher root-mean-square speed.
   (2) The mass of each gas molecule of *X* is the same as that of *Y*.
   (3) Both *X* and *Y* have no change in internal energy during the expansion from V_1 to V_2 .

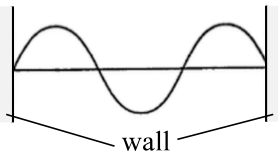
   A. (1) only
   B. (1) and (3) only
   C. (2) and (3) only
   D. (1), (2) and (3)

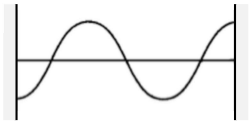
6. A travelling wave of period 5.0 ms travels through a medium. The displacement *y* against the position *x* at a certain time is shown in the graph below. What is the average speed of particle *P* during one complete oscillation?

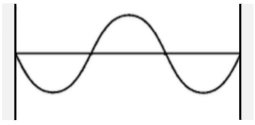


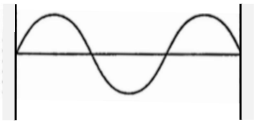
   A. 0 m s^{-1}
   B. 4.0 m s^{-1}
   C. 16 m s^{-1}
   D. 400 m s^{-1}

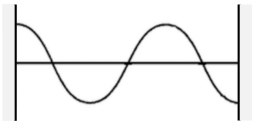
7. A stationary wave of frequency 50 Hz on a stretched string at time $t = 0$ s is shown. Which of the following correctly shows the shape of the string at $t = 0.010$ s ?



A. 

B. 

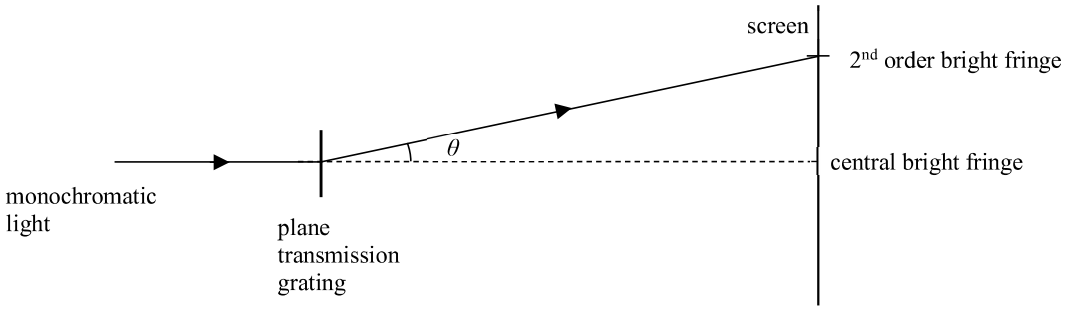
C. 

D. 

8. Consider a convex lens of focal length 20 cm . To form an image whose linear magnification is larger than 2 (i.e. $M \geq 2$), what is the maximum object distance?

A. 10 cm
B. 15 cm
C. 30 cm
D. 45 cm

9. A beam of monochromatic light is directed towards a plane transmission grating. A total number of 9 bright fringes are formed on the screen. Which of the following is a possible angle θ for the 2nd order bright fringe?



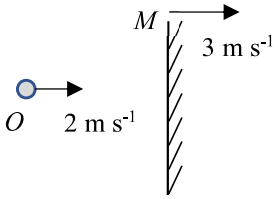
A. 14 °
B. 25 °
C. 36 °
D. 47 °

10. Which of the following is **not** an application of ultrasound?

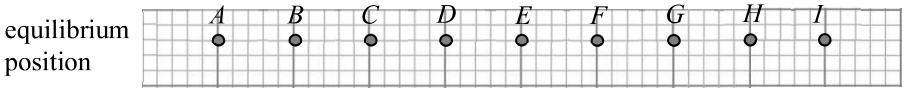
A. Detecting the depth of the sea and shoals of fish.
B. Detecting cracks in railway tracks.
C. Remote controlling a television.
D. Smashing kidney stones in the patient's body

11. An object O is placed in front of a mirror M . O and M are moving to the right at 2 m s^{-1} and 3 m s^{-1} respectively. What is the speed and the direction of movement of the image of O (not shown in the figure)?

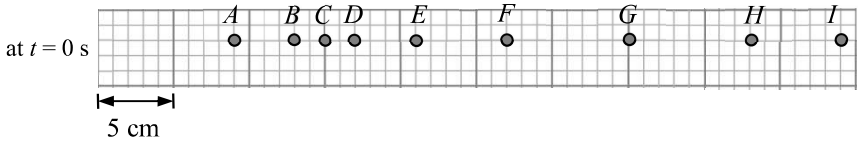
A. 2 m s^{-1} to the right
B. 2 m s^{-1} to the left
C. 4 m s^{-1} to the right
D. 4 m s^{-1} to the left



12. A longitudinal wave travels to the right through a medium at a wave speed of 4 cm s^{-1}. The equilibrium position of each medium particle is shown below:



The position of each medium particle at t = 0 s is shown below:

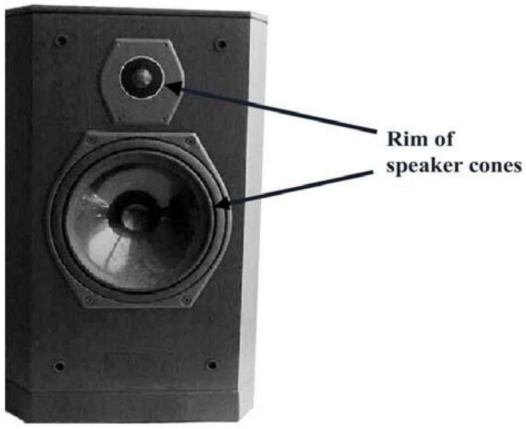


At which of the following moments is particle C momentarily at rest?

(1) t = 0 s
(2) t = 2.5 s
(3) t = 10 s

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

13. A loudspeaker with two speaker cones, a big one and small one, is shown. The sound waves generated by the speaker cones will bend around the rim of the cones. Which of the following statements are incorrect?

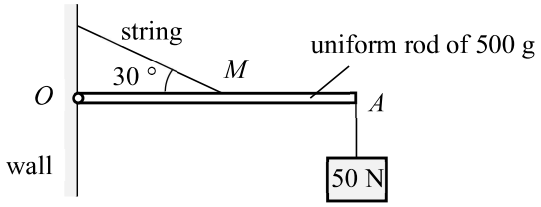


(1) The sound waves bend around the rim due to refraction.
(2) The bigger cone is more suitable for emitting high-pitch sounds.
(3) The sound emitted by the bigger cone travels faster in the air.

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

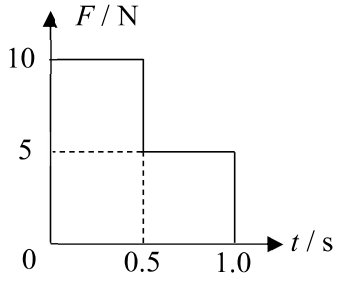
14. A uniform rod of mass 500 g is hinged at point O on a wall at one end. A weight of 50 N is attached to the other end A. The rod is held horizontally by a string attached to its mid-point M as shown. The angle between the rod and the string is $30\,°$. What is the magnitude of the total force acting on the rod by the wall at O?

A. 76.1 N
B. 173 N
C. 180 N
D. 188 N



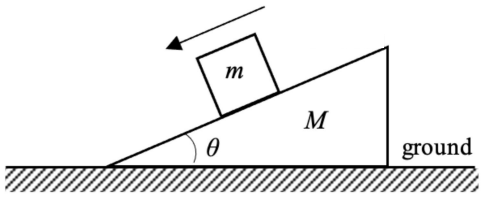
15. An object of 5 kg is initially moving at a constant velocity of 2 m s^{-1}. At time $t = 0$, an external force F whose direction is the same as the initial velocity acts on the object. The variation of the magnitude of F with time t is shown below.

What is the speed of the object after 1.0 s ?



A. 1.5 m s^{-1}
B. 2.0 m s^{-1}
C. 2.65 m s^{-1}
D. 3.50 m s^{-1}

16. A wedge with a rough surface is fixed on the horizontal ground. A block of mass m slides down the wedge at constant velocity.

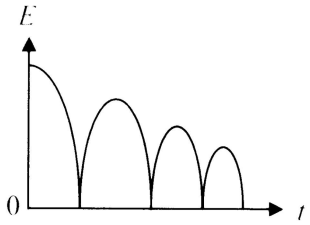


What is the total force acting on the wedge by the block?

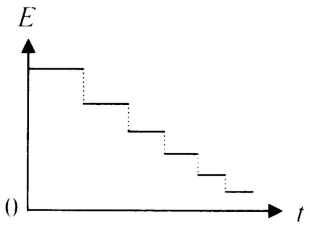
A. mg
B. $mg \sin^2 \theta$
C. $mg \cos^2 \theta$
D. $mg \sin \theta \cos \theta$

17. A ball released from a certain height hits the ground and bounces up from the floor several times before it comes to rest. Neglecting air resistance, which of the following graphs best represents how the total mechanical energy E varies with time t?

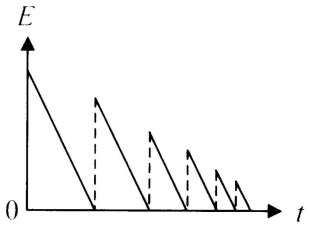
A.



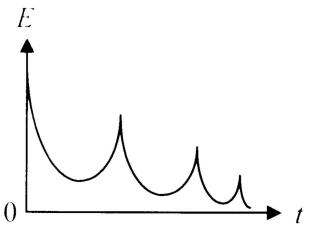
B.



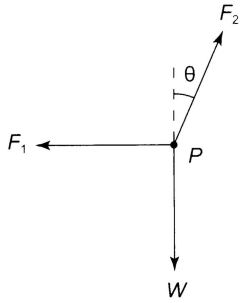
C.



D.



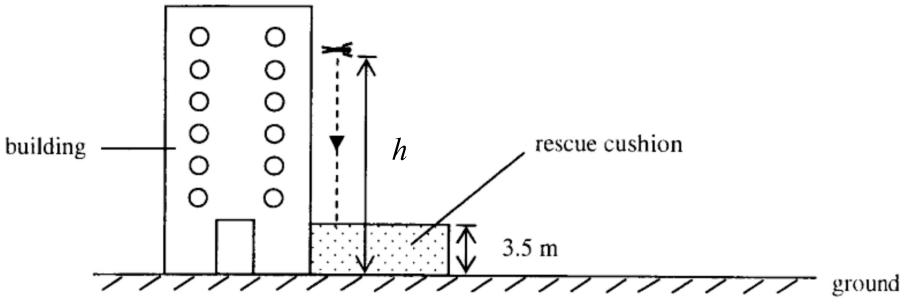
18. A particle P of weight W is acted on by two forces F_1 and F_2. F_1 is a horizontal force and F_2 makes an angle θ with the vertical. The particle P is at equilibrium. Which of the following statements about the magnitude of F_2 is / are correct?



(1) It is greater than the magnitude of F_1.
(2) It is greater than that the magnitude of W.
(3) It is smaller than the magnitude of the resultant of F_1 and W.

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

19. A fire breaks out in a building. A man of mass 60 kg falls vertically from rest from the building at a height h as shown. He is rescued by a cushion of thickness 3.5 m and his speed is 12.0 ms^{-1} when he just reaches the cushion. Neglect the size of the man and air resistance.

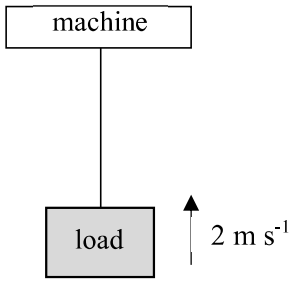


Estimate the height h.

A. 4.11 m
B. 7.34 m
C. 10.8 m
D. 14.7 m

20. A load of weight 600 N is pulled vertically upward at a constant speed of 2 m s^{-1} along a rope by a machine. Which of the following statements are correct?

(1) The tension in the rope is more than 600 N.
(2) The load gains potential energy at a rate of 1200 J s^{-1} .
(3) The output power of the machine is 1.2 kW .

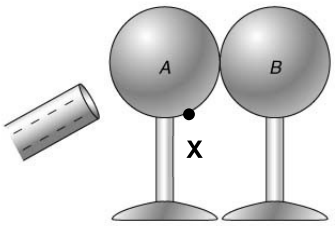


A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

21. A bomber explodes and splits into two pieces of unequal masses. The larger piece has a
(1) smaller speed
(2) smaller kinetic energy
(3) smaller magnitude of momentum

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

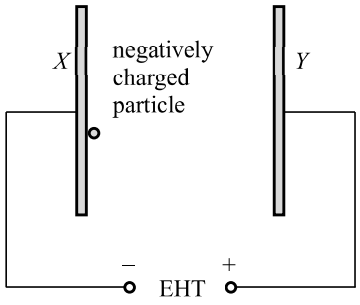
22. Two neutral, insulated metal spheres *A* and *B* are in contact. A negatively charge rod is brought close to *A* without touching it as shown in the figure. The point **X** on the surface of sphere *A* is then earthed. Which of the following is/are **correct**?



(1) *A* becomes neutral.
(2) *B* becomes neutral.
(3) Electrons flow to the earth through **X**.

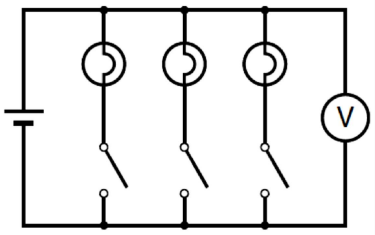
A. (1) only
B. (3) only
C. (1) and (3) only
D. (2) and (3) only

23. Two parallel plates, *X* and *Y*, at a separation *d* are connected to an extra high tension (EHT) with an output voltage *V* . A negatively-charged particle is accelerated from rest at *X* through the gap. Assume that the particle is acted upon by electrostatic force only. The speed acquired by the particle just before it reaches *Y* is independent of



A. the mass of the particle.
B. the charge of the particle.
C. the separation between two plates, *d*.
D. the output of the EHT, *V*.

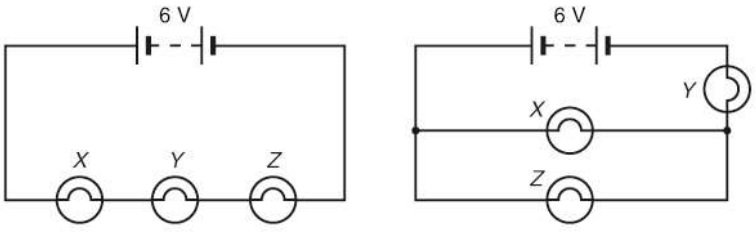
24. A battery of e.m.f. ε and internal resistance *r* is connected to the circuit as shown. The voltmeter is ideal and the resistance of each light bulb is 9 times the internal resistance. The initial voltmeter reading is V_o. The switches are then closed one by one. Which of the following statements is / are **correct**?



(1) The e.m.f. of the battery is V_o.
(2) The voltmeter reading is inversely proportional to the current drawn from the battery.
(3) 25% of the power from the battery is lost to the heat dissipation of the internal resistance when all switches are closed.

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

25. Three light bulbs *X*, *Y* and *Z* of rating '6 V, 9 W', '6 V, 12 W' and '6 V, 15 W' respectively are connected to a 6 V battery in two different ways as shown in the figures below.



Case *A* Case *B*

Which light bulb is operating at the smallest power in each case?

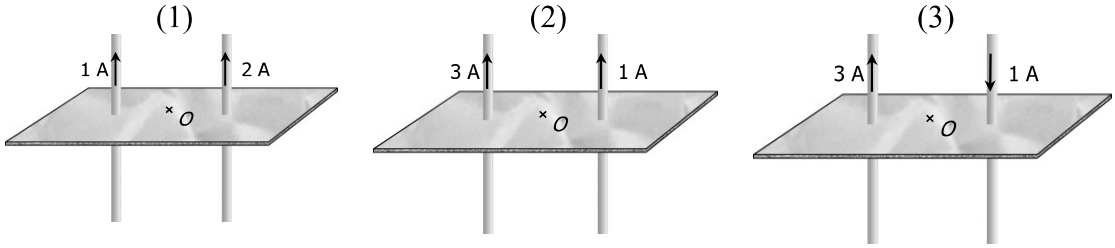
	Case *A*	**Case *B***
A.	*X*	*X*
B.	*X*	*Y*
C.	*Z*	*X*
D.	*Z*	*Y*

26. Which of the following units of magnetic field is / are correct?

(1) Wb m^{-2}
(2) T m A^{-1}
(3) N A^{-1} m^{-1}

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

27. In the figures below, *O* is the midpoint between each pair of parallel straight wires.

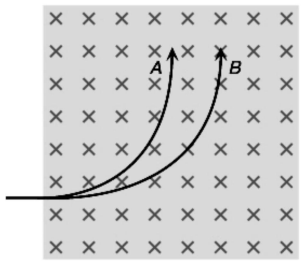


like currents like currents unlike currents

Which of the following shows the correct order of magnetic field strength at *O*?

A. (1) < (2) = (3)
B. (1) < (2) < (3)
C. (3) < (1) < (2)
D. (2) < (1) < (3)

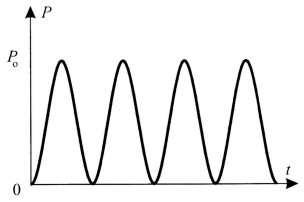
28. At the same position, two particles A and B enter a uniform magnetic field with the same speed to the right. The field direction is into the paper and the paths of A and B inside the magnetic field are as shown. They have the same charge sign and magnitude. Which of the following statements are **incorrect**?



(1) The mass of A is larger than that of B.
(2) Both A and B are positive charges.
(3) The magnitude of the magnetic force acting on A is greater than that of B.

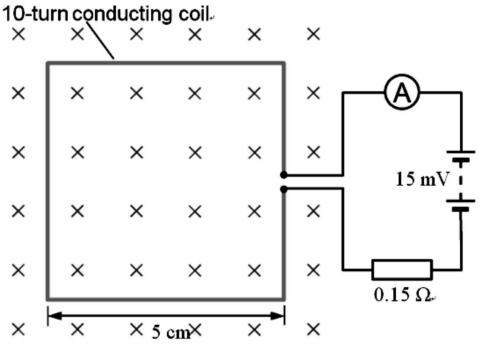
A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

29. An a.c. voltage of r.m.s. value 10 V is applied to two 20 Ω resistors connected in parallel. The graph shows the time variation of the total power dissipation of the two resistors. What is the peak power P_o ?



A. 2.5 W
B. 5 W
C. 10 W
D. 20 W

30. A 10-turn square conducting coil, a 0.15 Ω resistor, a battery of e.m.f 15 mV and an ammeter are connected into a circuit a shown. A uniform magnetic field is applied perpendicularly to the coil and its magnitude is decreasing at a constant rate of 0.10 T s^{-1}. Which of the following statements is / are **correct**?



(1) The direction of induced current through the coil is clockwise.
(2) The ammeter reading is 117 mA.
(3) The ammeter reading is zero when the magnetic field is kept constant.

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

31. The number of undecayed nuclei N of a radioactive sample is found to be related to the activity A (in s^{-1}) by the relationship $N = 4 \times 10^5 A$. Find the time taken for the sample to decay by 80%.

A. 5.6×10^{-7} s
B. 4.0×10^{-6} s
C. 1.0 day
D. 7.5 days

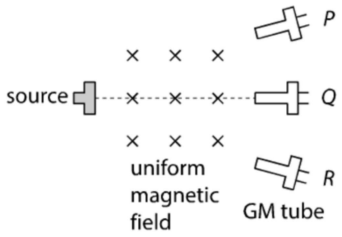
32. Which of the following average background count rates in Hong Kong is / are normal?

(1) 1 count per second
(2) 5 counts per second
(3) 10 counts per second

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

33. A radioactive source, which emits β and γ radiations only, is contained in a lead box with a small opening directed towards a uniform magnetic field pointing into paper. When a GM tube is placed at point *P*, *Q* and *R* , the recorded count rates are 60, 70 and 90 counts per minute respectively. When the magnetic field is removed, which of the following gives the best estimation of the count rate recorded at point *Q* ?

A. 220 counts per minute
B. 100 counts per minute
C. 90 counts per minute
D. Cannot be determined as the background count rate is not given.



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 = 1.661×10^{-27} kg (1 u is equivalent to 931 MeV)
astronomical unit	AU = 1.50×10^{11} m
light year	ly = 9.46×10^{15} m
parsec	pc = 3.09×10^{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)
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 separation 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