Name: _____( ) Class: 21 / _____

ANDERSON SERANGOON JUNIOR COLLEGE

2021 JC2 Preliminary Examination

PHYSICS Higher 2 — 9749/01

Paper 1 Multiple Choice — **Tuesday 21 September 2021**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and class on the Multiple Choice Answer Sheet.
Shade and write your NRIC/FIN.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Multiple Choice Answer Sheet.

Read the instructions on the Multiple Choice Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this question paper.
The use of an approved scientific calculator is expected, where appropriate.

CLT Notice

Questions set on the Common Last Topic of the syllabus do not form part of the assessment. They will not be marked by the Examiners.

Do **not** answer the following questions:
Question 30 on page 16

Turn to these questions and cross them out by drawing a line through these questions.
The total time allowed for this Question Paper has **not** been changed.
The total mark allowed for this Question Paper is now **29**.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm \omega\sqrt{x_o^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 The table shows some measurable quantities.

Which row gives the correct order of magnitude of the measurable quantity in the stated unit?

	measurable quantity	order of magnitude	unit
A	mass of a coin	10^{-4}	kg
B	thickness of a sheet of paper	10^{-2}	m
C	weight of an apple	10^{0}	N
D	temperature of a person's body	10^{1}	K

2 A micrometer is used to measure the diameters of two cylinders.

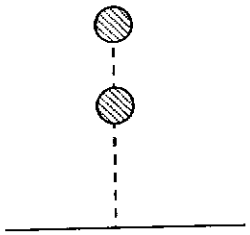
diameter of first cylinder = (12.78 ± 0.02) mm
diameter of second cylinder = (16.24 ± 0.03) mm

The difference in the diameters is calculated.

What is the percentage uncertainty in this difference?

A 0.29 B 0.58 C 0.87 D 1.4

3 Two identical stones are simultaneously released from rest from different heights as shown. Air resistance is negligible.



As the stones fall, which of the following is true about the distance between them?

A The distance will increase continuously.

B The distance will decrease until they touch.

C The distance will remain the same.

D The distance will increase initially then remain the same.

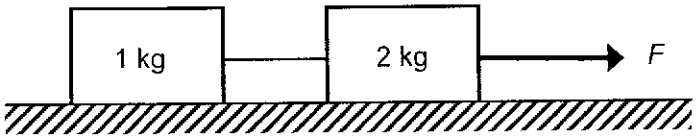
4 A person of mass 60 kg stands on an accurate bathroom scale, placed on the floor of a lift which operates in a tall building.

At a certain instant the bathroom scale reads 58 kg.

Which row could give the person's direction of movement and type of motion?

	direction	motion
A	downwards	constant speed
B	downwards	slowing down
C	upwards	constant speed
D	upwards	slowing down

5 The frictionless system shown is accelerated by an applied force of magnitude F.



What is the tension in the string between the blocks?

A $\frac{1}{3}F$ **B** $\frac{1}{2}F$ **C** F **D** $2F$

6 A molecule of mass m travels with velocity $+u$ directly towards a stationary molecule of mass $4m$ and collides elastically with it.

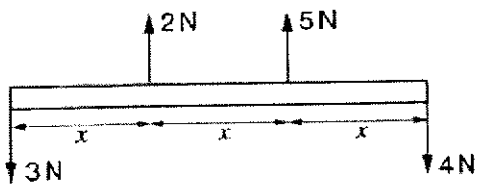
What is the velocity of the molecule of mass m after the collision?

A $+\frac{u}{5}$ **B** $-\frac{3}{5}u$ **C** $-\frac{4}{5}u$ **D** $-u$

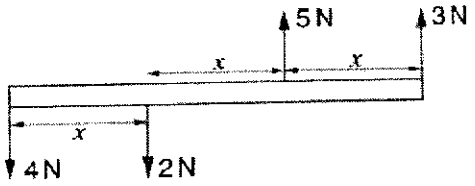
7 The force diagrams show all the forces acting on a beam of length $3x$.

Which force system causes only rotational motion of the beam without any linear movement?

A



B



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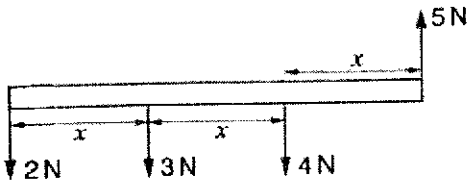
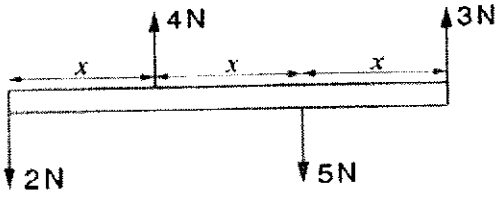


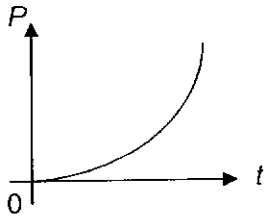
D



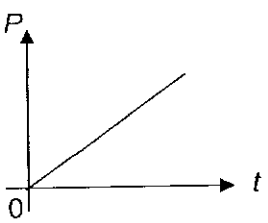
8 An object resting on a horizontal frictionless surface is accelerated from rest by a constant force from a motor.

Which of the following graphs shows the variation of the motor power P with time t ?

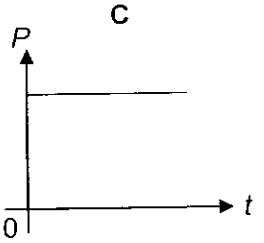
A



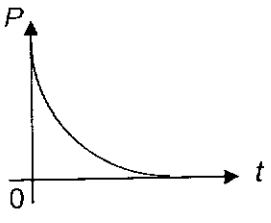
B



C



D



9 Two ice boats, of masses m and $2m$, are made to compete in a race on a frictionless frozen lake. The boats have identical sails so that the wind pushes them forward with the same force. The two boats start from rest and travel the same distance.

Which of the following statements is correct?

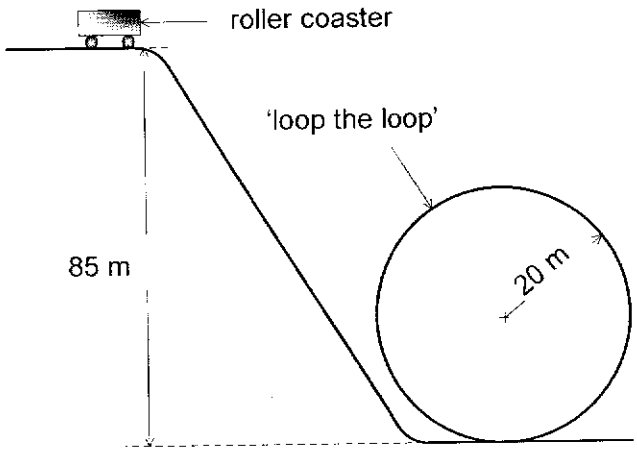
A The boat of mass m will win the race but the two boats will have the same final speed.

B The boat of mass m will win the race but it will have a lower final kinetic energy.

C The boat of mass m will win the race and it will have a higher final kinetic energy.

D The boat of mass m will win the race but the two boats will have the same final kinetic energy.

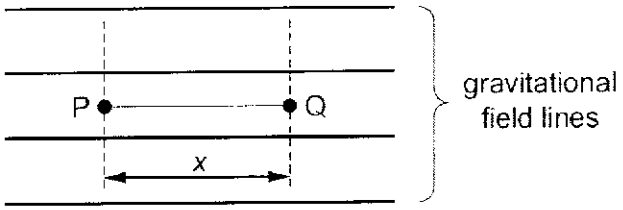
10 A roller coaster starts from rest on a hill-top. It accelerates along a frictionless track before entering a loop-the-loop of radius 20 m as shown below.



What is the minimum normal contact force that the roller coaster seat exerts on a passenger with weight W, as it passes through the 'loop the loop'?

A 0 **B** 3.5 W **C** 4.5 W **D** 5.5 W

11 A mass m is situated in a uniform gravitational field.



When the mass moves through a displacement x, from P to Q, it loses an amount of potential energy E.

Which row correctly specifies the magnitude and the direction of the acceleration due to gravity in this field?

	magnitude	direction
A	$\frac{E}{mx}$	→
B	$\frac{E}{mx}$	←
C	$\frac{E}{x}$	→
D	$\frac{E}{x}$	←

12 Cooling water enters the heat exchanger in the turbine hall of a nuclear power station at 6.0 °C and leaves at 14.0 °C. The rate of heat removal by the water is 6.7×10^9 J per minute.

The specific heat capacity of water is 4200 J $kg^{-1}K^{-1}$.

What is the rate of water flow?

A $\frac{6.7\times10^9\times60}{4200\times8}\,kg\,s^{-1}$

B $\frac{6.7\times10^9}{4200\times8\times60}\,kg\,s^{-1}$

C $\frac{4200\times8}{6.7\times10^9\times60}\,kg\,s^{-1}$

D $\frac{4200\times8\times60}{6.7\times10^9}\,kg\,s^{-1}$

13 Air is enclosed in a cylinder by a gas-tight, frictionless piston of cross-sectional area 3.0×10^{-3} m^2. When atmospheric pressure is 100k Pa, the piston settles 80 mm from the end of the cylinder (see diagram 1).

The piston is then pulled out until it is 160 mm from the end of the cylinder (see diagram 2) and is held there. The temperature of the air in the cylinder returns to its original value.

diagram 1

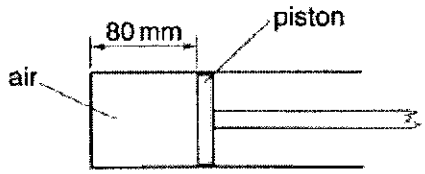
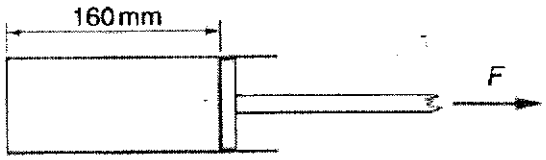


diagram 2



What is the force F required to hold the piston in its new position?

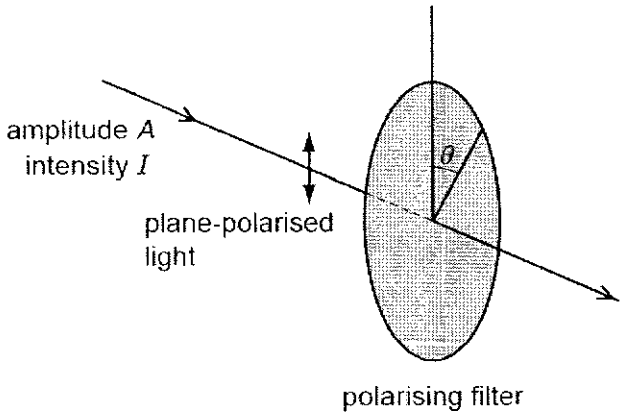
A 150 N **B** 200 N **C** 300 N **D** 600 N

14 An object placed on a horizontal platform is oscillating vertically in simple harmonic motion with a frequency of 1.5 Hz.

What is the maximum amplitude of oscillation that will allow the object to remain in contact with the platform throughout the motion?

A 0.11 m **B** 1.0 m **C** 6.5 m **D** 9.0 m

15 A plane-polarised light of amplitude A is passed through a polarising filter as shown below.

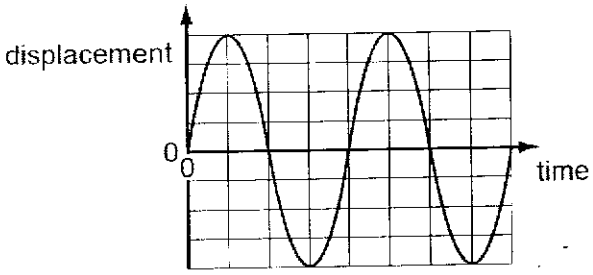


The intensity of the initial beam is I.

What is the intensity of the emerging light when θ is 60.0°?

A 0.250 I **B** 0.500 I **C** 0.750 I **D** 0.866 I

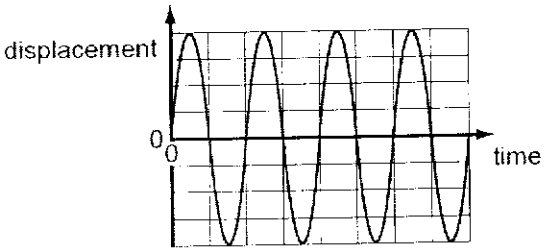
16 The diagram shows a graph of displacement against time for a sound wave.



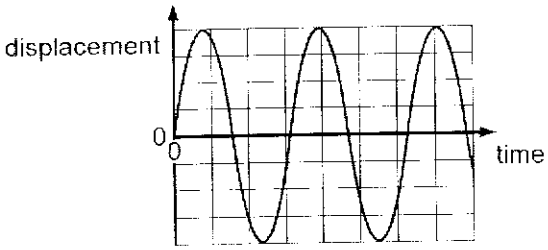
The intensity of the sound is halved.

Which graph shows the new displacement of this sound wave?

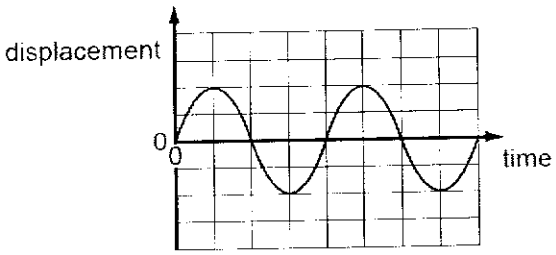
A



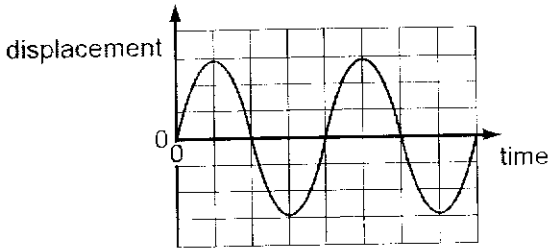
B



C



D



17 The interference patterns from a diffraction grating and a double slit are compared.

Using the diffraction grating, yellow light of the first order is seen at 30° to the normal to the grating.

The same light produces interference fringes on a screen 1.0 m from the double slit. The slit separation is 500 times greater than the line spacing of the grating.

What is the fringe separation on the screen?

A 2.5×10^{-7} m

B 1.0×10^{-5} m

C 1.0×10^{-3} m

D 1.0×10^{-1} m

18 A double star is at a distance of 20 light years from the Earth. A telescope with a diameter of 3.0 m is used to view the star.

(A light year is the distance light travels in a vacuum in one year. This is 9.5×10^{15} m.)

What is the approximate minimum separation between the two stars of the double star that can be detected by the telescope?

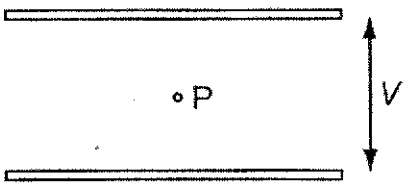
A 5.0×10^{8} m

B 1.0×10^{9} m

C 3.0×10^{10} m

D 3.0×10^{11} m

19 A small positively charged particle P is balanced halfway between two horizontal plates when a potential difference V is applied between the plates.



When V is increased, P rises towards the upper plate.

When V is decreased, P falls towards the lower plate.

Which statement is correct?

A Decreasing V increases both the electric and the gravitational potential energy of the particle.

B Decreasing V increases the electric potential energy and decreases the gravitational potential energy of the particle.

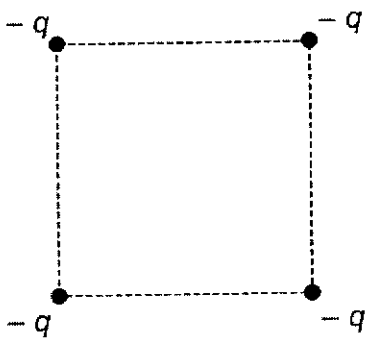
C Increasing V increases both the electric and the gravitational potential energy of the particle.

D The change of electric potential energy of the particle must equal the change of gravitational potential energy of the particle.

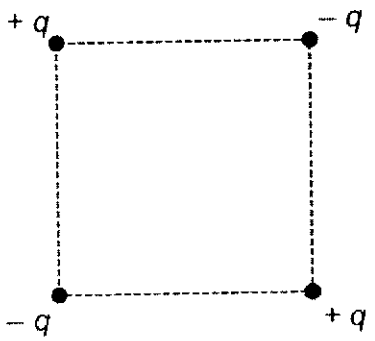
20 Point charges, each of magnitude q, are arranged at the corners of a square.

For which arrangement will the magnitude of the resultant electric field strength at the centre of the square be the largest?

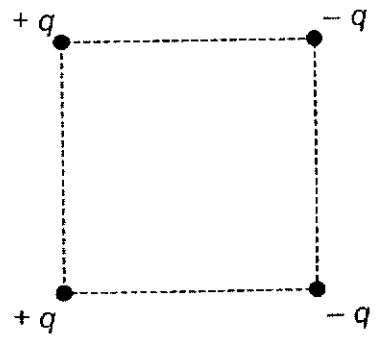
A



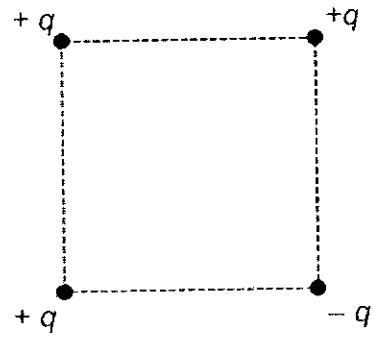
B



C



D

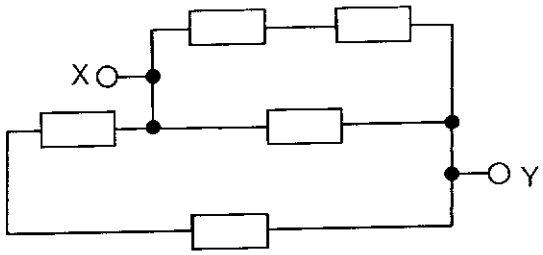


21 Protons in a parallel beam each move at a uniform velocity v, thus forming a current I. the charge on each proton is e.

Which expression represents the number of protons present in unit length of the beam?

A $\frac{I}{e}$ **B** $\frac{I}{ev}$ **C** $\frac{Iv}{e}$ **D** $\frac{I}{v}$

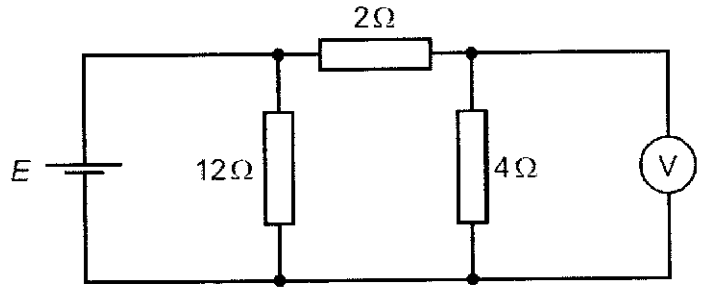
22 The circuit diagram shows a network of resistors each of resistance R.



What is the effective resistance between the points X and Y?

A $\frac{2}{3}R$ **B** $\frac{5}{8}R$ **C** $\frac{R}{2}$ **D** $\frac{2}{7}R$

23 A cell of electromotive force (e.m.f.) E and negligible internal resistance is connected into a circuit, as shown.

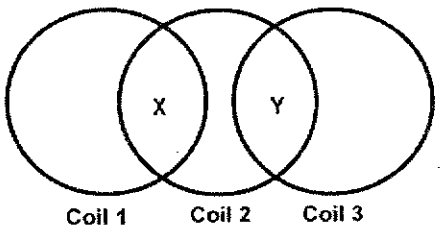


The voltmeter has a very high resistance and reads a potential difference V_{out}.

What is the ratio $\frac{V_{out}}{E}$?

A $\frac{1}{6}$ **B** $\frac{1}{3}$ **C** $\frac{1}{2}$ **D** $\frac{2}{3}$

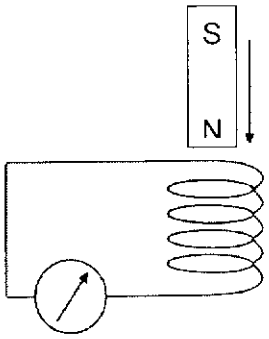
24 Three insulated coils of wires are placed on top of one another such that there are overlapping regions. Each of the coils carries identical current but their directions are unknown. Region X is found to have a resultant magnetic field pointing out of the paper while region Y is found to have a magnetic flux density of near zero.



Which of the following is a possible configuration of the direction of flow of the currents in the coils?

	Coil 1	Coil 2	Coil 3
A	clockwise	clockwise	counterclockwise
B	clockwise	counterclockwise	counterclockwise
C	counterclockwise	clockwise	clockwise
D	counterclockwise	counterclockwise	clockwise

25 A bar magnet is dropped vertically above a coil that is connected to a galvanometer. As the magnet approaches the coil, the galvanometer deflects to the right by 10 units.



What is the deflection of the galvanometer as the magnet leaves the coil?

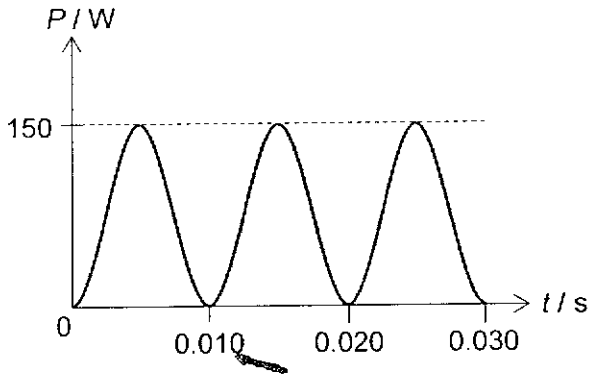
A To the left by less than 10 units

B To the left by more than 10 units

C To the right by less than 10 units

D To the right by more than 10 units

26 The graph shows the variation with time t of the power P dissipated in a resistor of resistance 6.0 Ω when it is connected to an alternating supply.



Which equation represents the sinusoidal alternating current through the resistor?

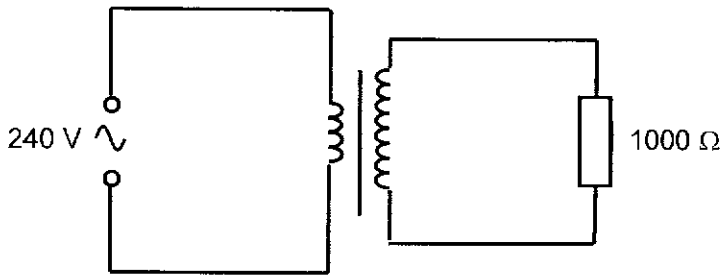
A $I = 5.0 \sin 100\pi t$

B $I = 5.0 \sin 200\pi t$

C $I = 25 \sin 100\pi t$

D $I = 25 \sin 300\pi t$

27 An ideal transformer is used to step-up a 240 V a.c. power supply. The output is used to heat a 1000 Ω resistive load. The ratio of the primary turns to secondary turns is 1:5.



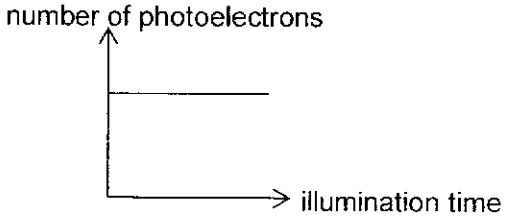
What is the current in the primary coil?

A 0.24 A **B** 1.2 A **C** 6.0 A **D** 36 A

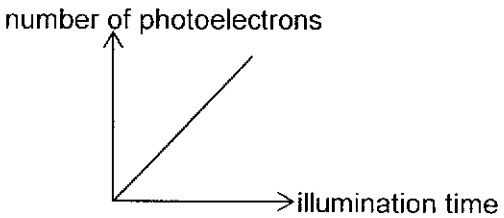
28 When electromagnetic radiation of frequency f illuminates on a particular metal surface, photoelectrons are emitted.

Which graph is obtained when the intensity of the electromagnetic radiation is kept constant?

A



B



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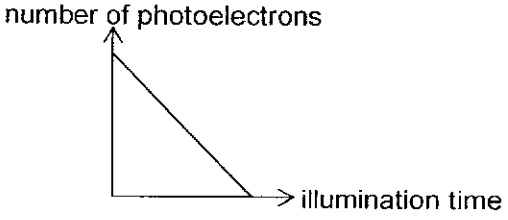
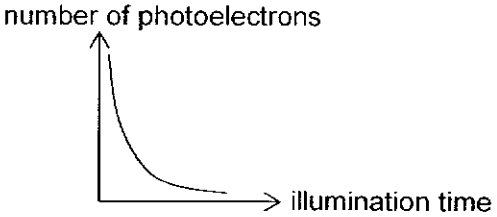


D



29 The accelerating potential difference in an X-ray tube is 20 kV.

What is the shortest wavelength of the X-ray photon emitted from the X-ray tube?

A 1.6×10^{-11} m

B 6.2×10^{-11} m

C 1.6×10^{-10} m

D 6.2×10^{-10} m

30 The symbol $^{130}_{52}Te$ represents a nuclide of tellurium that undergoes a double beta decay to become a nuclide of xenon (Xe).

What is the symbol of this xenon nuclide?

A $^{128}_{54}Xe$ **B** $^{129}_{54}Xe$ **C** $^{130}_{53}Xe$ **D** $^{130}_{54}Xe$

Anderson Serangoon Junior College 2021 H2 Physics Prelim Mark Scheme

Paper 1 (29 marks)

1	2	3	4	5	6	7	8	9	10
C	D	C	D	A	B	D	B	D	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	B	A	A	A	D	C	C	B	C
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
B	C	D	D	B	A	C	B	B	

1 **C**

coin mass – 10^{-3} kg; paper thickness – 10^{-4} m; body temperature – 10^{2} K

2 **D**

$d_2 - d_1 = 3.46$ mm
$\Delta(d_2 - d_1) = \Delta(d_2) + \Delta(d_1) = 0.03 + 0.02 = 0.05$ mm

$$\frac{\Delta(d_2 - d_1)}{d_2 - d_1} \times 100\% = \frac{0.05}{3.46} \times 100\% = 1.4\%$$

3 **C**

Initial velocities for both stones, $u = 0$

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

For the same time interval, Δt, both stones fall down by the same distance, s.

Therefore the distance between them will always remain the same as that at the point of release.

4 **D**

Since bathroom scales reading (which is equal to contact force from scale on person) is less than weight, the net force on person is downwards. The acceleration of the person is directed downwards. This applies either when the person is moving downwards is speeding up, or when the person is moving upwards and slowing down.

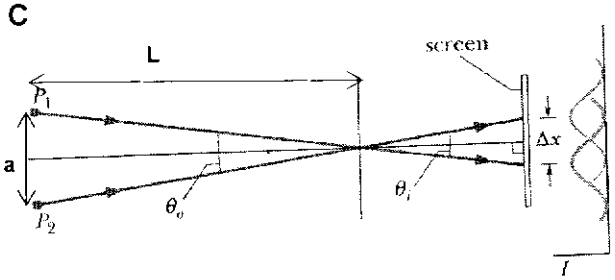
A and C are wrong as the person has acceleration, so cannot be moving at constant speed.
B is wrong. When movement is downwards and slowing down, acceleration is upwards.

5 **A**

	System of two mass: F = 3 (a) $a = \frac{F}{3}$ System of 1 kg mass: T = (1.0) $(\frac{F}{3})$ $= \frac{F}{3}$
6	**B** For elastic collisions, the relative speed of approach equals relative speed of separation $u - 0 = v_2 - v_1$ $v_2 = u + v_1$ (1) From conservation of linear momentum $mu + 0 = mv_1 + 4mv_2$ (2) Substituting (1) into (2) $mu = mv_1 + 4m(u + v_1)$ $5v_1 = -3u$ $v_1 = -\frac{3}{5}u$
7	**D** To have only rotational motion, net force = 0 but net moment ≠ 0. B and C are wrong as net force is not zero, so system causes linear movement of the rod. A is wrong as moments about any point is zero, hence no rotational movement. D is correct as moments about any point is not zero, hence there is rotational movement.
8	**B** $P = Fv = F(u + at) = F(0 + at) = Fat$ Since F and a are constants, P varies linearly with t.
9	**D** Both boats travel the same distance s and experience the same force F. Hence the total work done by the force F between the starting line and the finishing line is the same for each boat – they will have the same final kinetic energy. Boat with mass m will experience a larger acceleration, and will thus reach the finish line first. Note: Boat with mass m will also have a higher speed, since the two boats have the same final kinetic energy.

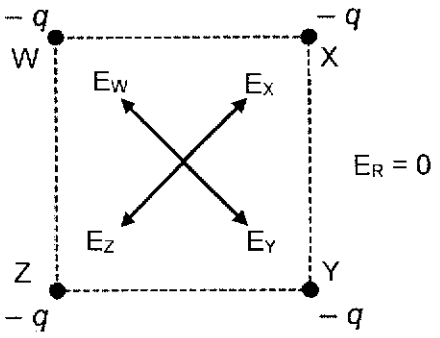
10	**B**

	Compare mechanical enery at hilltop to that at top of loop. By Conservation of Energy, gain in KE = loss in GPE $\frac{1}{2}mv^2 - 0 = mg\,(h_{hilltop} - h_{top\ of\ loop})$ $F_{net} = \frac{mv^2}{r} = \frac{2mg\,(85-40)}{20}$ $N + mg = \frac{9}{2}mg$ (at top of loop) $N = 3.5mg = 3.5W$
11	**A** Since $\Delta\phi = \frac{E}{m}$, magnitude of g $= \frac{\Delta\phi}{x} = \frac{E}{mx}$ Potential at P > potential at Q since mass loses potential energy as it moves from P to Q. Hence, direction of g is from P to Q, higher potential to lower potential.
12	**B** Rate of heat removed = rate of water flow × c × temp change Q/t = (m/t) c $\Delta\theta$ m/t = $\frac{\frac{6.7\times10^9}{60}}{4200\times(14-6)}\,kg\,s^{-1} = \frac{6.7\times10^9}{4200\times8\times60}\,kg\,s^{-1}$
13	**A** Let A = cross-sectional area of piston Since no change in temperature, $p_1V_1 = p_2V_2$ p_2 = (100 kPa × 80 mm × A) / (160 mm × A) = 50 kPa $\therefore F$ = (atm pressure – p_2)A = (100 – 50) $10^3 \times 3 \times 10^{-3}$ =150 N
14	**A** For the object to remain in contact with the platform throughout the motion, its acceleration must not be greater than 9.81 m s^{-2}. $a_{max} = \omega^2 x_0$ $x_0 = \frac{a_{max}}{\omega^2} = \frac{a_{max}}{(2\pi f)^2} = \frac{9.81}{(2\pi(1.5))^2} = 0.11\,m$
15	**A**

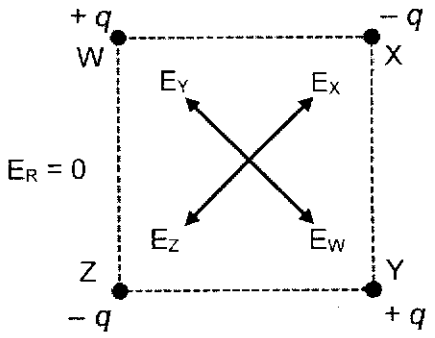
	Intensity = $I\cos^2\theta = I\cos^2(60.0°) = 0.250\,I$
16	**D** Since intensity, I varies proportionately with (amplitude, A)^2 Let each unit for displacement be y. $\frac{I_{new}}{I_{old}} = \left(\frac{A_{new}}{A_{old}}\right)^2$ $\frac{0.5I_{old}}{I_{old}} = \left(\frac{A_{new}}{4y}\right)^2$ $A_{new} = 2.8y$
17	**C** d sinθ = nλ, so sin 30° = λ/d x = λD/a = λD/ 500d = (1.0/500) sin 30° = 1.0×10^{-3} m
18	**C**  P_1 and P_2 are the double stars. The angular separation θ_o of the 2 stars equals the angular separation θ_i of the images. i.e.$\theta_o = \theta_i$ If the images are to satisfy Rayleigh's criterion for resolvability, then $\theta_o = \theta_I = \theta_R = \frac{\lambda}{D}$, where D = diameter of the lens Hence $\frac{a}{L} = \frac{\lambda}{D}$, taking λ = 500 nm for visible light $\frac{a}{20 \times 9.5 \times 10^{15}} = \frac{500 \times 10^{-9}}{3.0}$ a = 3.2×10^{10} m
19	**B** In order to hold the positively-charged particle P halfway between the two plates, the upper plate must be at a lower potential with respect to the lower plate (so that electric force acts upwards which is balanced by the gravitational force acting downwards). By decreasing V and causing the positively-charged particle P to move towards the lower plate (which is at a higher potential), the EPE of the particle increases (since a positive charge's EPE increases with electric potential). However, as the particle has fallen to a lower position, its GPE decreases.
20	**C**

Let E_R denote the resultant electric field strength at the centre of the square.

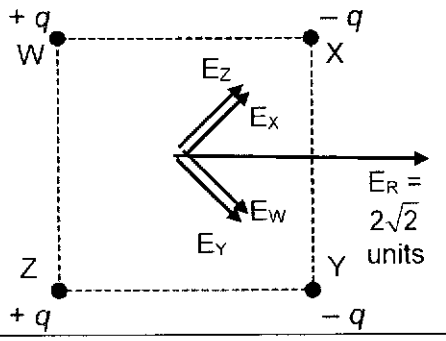
A



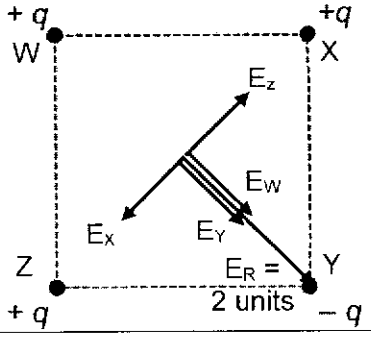
B



C



D

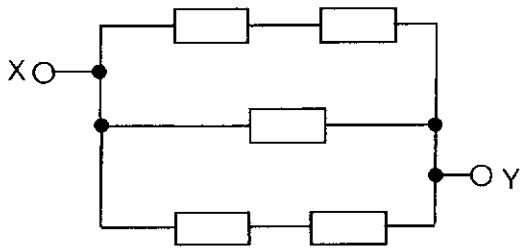


21 **B**

Use $I = evAn$

$An = I/ev$ where An is the number of protons per unit length.

22 **C**



$$\frac{1}{R_{eff}} = \frac{1}{2R} + \frac{1}{R} + \frac{1}{2R}$$

$$R_{eff} = \frac{R}{2}$$

23 **D**

2Ω and 4Ω are connected in series, and they are connected parallel with the cell.

V_{out} is the p.d. across 4Ω

Using potential divider, $V_{out} = \frac{4}{4+2}(E)$

$$\frac{V_{out}}{E} = \frac{2}{3}$$

24 **D**

	The direction of the flux density due to coil 1 and 2 must be in the same direction while direction of flux density due to coil 2 and 3 must be in opposite direction. By using Right Hand Grip Rule, we can conclude that the current in coil 1 and 2 must be CCW such that magnetic flux is out of the plane while current in coil 3 must be CW to achieve near zero magnetic flux density.
25	**B** As magnet leaves the coil, induced emf acts in the opposite direction, hence galvanometer deflects in the opposite direction. Magnitude is larger than 10 units due to acceleration of the magnet during the fall.
26	**A** $I = I_0 \sin \omega t = \sqrt{\frac{P_0}{R}} \sin \frac{2\pi}{T} t = \sqrt{\frac{150}{6.0}} \sin \frac{2\pi}{0.020} t$ $I = 5.0 \sin 100\pi t$
27	**C** $\frac{V_S}{V_P} = \frac{5}{1} \quad \Rightarrow \quad V_S = 5 \times 240 = 1200 \text{ V}$ Power delivered to the resistive load $P = \frac{V^2}{R} = \frac{1200^2}{1000} = 1440 \text{ W}$ Ideal transformer implies 100% efficiency. Power supplied by primary circuit $P = VI = 240I = 1440 \quad \Rightarrow \quad I = \frac{1440}{240} = 6.0 \text{ A}$
28	**B** The number of photoelectrons emitted per second $(\frac{N}{t})$ is directly proportional to the intensity of incident radiation. Since the intensity of radiation is constant, the number of photoelectrons varies proportional with time.
29	**B** The potential energy gained by the electron = $qV = 3.2 \times 10^{-15}$ J $\frac{hc}{\lambda} = 3.2 \times 10^{-15}$ J $\lambda = 6.2 \times 10^{-11}$ m
30	**D** Beta decay occurs when a neutron in the nucleus decays to produce a proton, a beta electron and an anti-electron-type neutrino. With each beta decay, the mass number of the daughter nucleus remains unchanged but the atomic number increases by one. Hence, after double beta decay, the mass number of the daughter nucleus remains unchanged at 130 and the atomic number increases by two to 54. $^{130}_{52}\text{Te} \rightarrow {}^{A}_{Z}\text{Xe} + 2\,{}^{0}_{-1}\beta$ Therefore, Z = 54 and A = 130.