TEMASEK JUNIOR COLLEGE
2024 JC2 PRELIMINARY EXAMINATION
Higher 2

TEMASEK JUNIOR COLLEGE

PHYSICS

9749/01

Paper 1 Multiple Choice

12 September 2024

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 Civics group on the Answer Sheet in the spaces provided.

There are **thirty** questions in 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 Answer Sheet.

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 booklet.
The use of an approved scientific calculator is expected, where appropriate.

Do NOT open the booklets until you are told to do so.

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	$p = \rho g h$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/^{\circ}\text{C} + 273.15$
pressure of an ideal gas	$p = \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \dfrac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t = \pm\omega\sqrt{x_0^2 - x^2}$
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	$V = Q/(4\pi\varepsilon_0 r)$
alternating current / voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \dfrac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{\ln 2}{t_{\frac{1}{2}}}$

1 The speed v of a liquid leaving a tube depends on the change in pressure ΔP and the density ρ the liquid. The speed is given by the equation

$$v = k(\frac{\Delta P}{\rho})^n$$

where k is a constant that has no unit.

What is the value of n?

A 0.5 **B** 1 **C** 1.5 **D** 2

2 A student made a series of measurements of the diameter d, of a wire using four micrometer screw gauges A, B, C and D. The table shows the measurements taken.

If the actual diameter of the wire was 1.49 mm, which micrometer screw gauge produced a set of readings that could be described as accurate but not precise?

micrometer screw gauge	readings d/ mm			
A	1.49	1.46	1.52	1.50
B	1.48	1.58	1.51	1.40
C	1.35	1.37	1.42	1.42
D	1.32	1.37	1.41	1.50

3 An aircraft flies with airspeed of 350 km h^{-1} through a 100 km h^{-1} jet-stream wind from the west. The pilot wishes to fly directly north from an airport in Singapore to an airport Thailand. To achieve this, the pilot points the aircraft away from the north direction.

What is the speed of the aircraft in the direction of north relative to the ground?

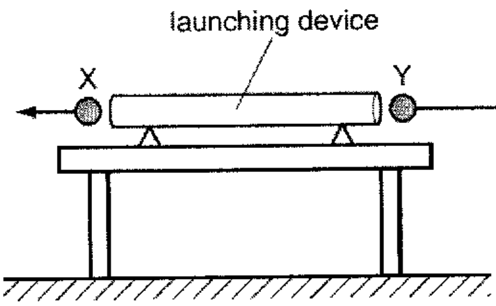
A 250 km h^{-1}

B 335 km h^{-1}

C 364 km h^{-1}

D 450 km h^{-1}

4 A double-ended launching device fires two identical steel balls X and Y at exactly the same time. The diagram shows the initial velocities of the balls. They are both launched horizontally, but Y has greater speed.



Which statement explains what an observer would see?

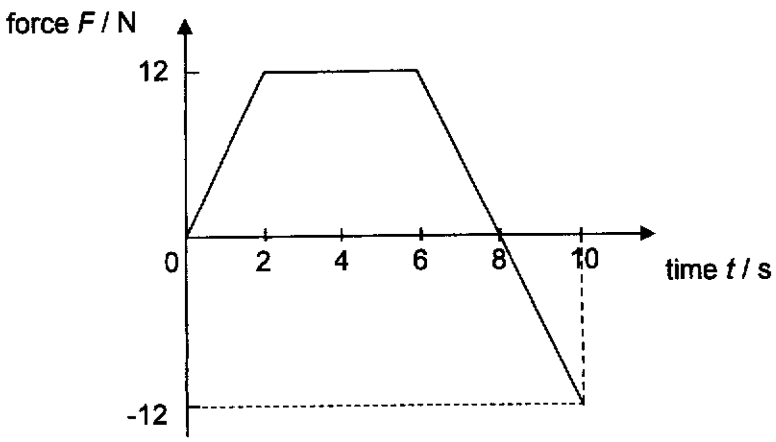
A X reaches the ground before Y, because X lands nearer to the launcher.

B Y reaches the ground before X, because Y has greater initial speed.

C Both X and Y reach the ground simultaneously, because gravitational acceleration is the same for both.

D Both X and Y reach the ground simultaneously, because air resistance will cause both to have the same final speed.

5 A body of mass 300 g initially at rest is acted on by a force F which varies with time t as shown in the diagram below.



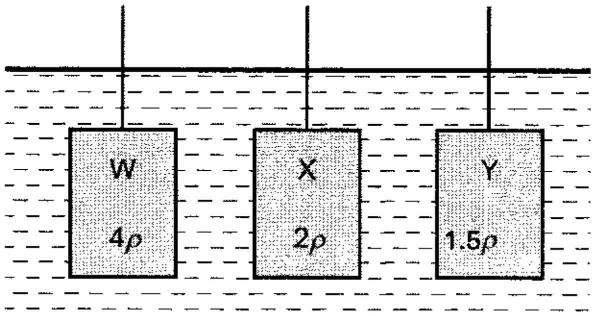
What is the speed of the body at the 10th second?

A 200 m s^{-1} **B** 240 m s^{-1} **C** 260 m s^{-1} **D** 280 m s^{-1}

6 A jet of water of density 1000 kg m^{-3} leaves the nozzle of a hose of radius 2.0×10^{-2} m. The water is directed perpendicularly to the wall at a speed of 0.50 m s^{-1}. Assume that the water does not rebound.
What is the force exerted on the wall by the water?

A 0.314 N **B** 0.628 N **C** 1.27 N **D** 15.7 N

7 Three cuboids with identical dimensions are fully immersed in water as shown. The cuboids are held by strings in identical orientations by strings and in equilibrium at the same depth.



Water has density ρ.

Cuboid W is made of material of density 4ρ.

Cuboid X is made of material of density 2 ρ.

Cuboid Y is made of material of density 1.5 ρ.

Which statement is correct?

A The upthrust on cuboid Y is equal to weight of cuboid Y.

B The upthrust on cuboid W is two times the upthrust on cuboid X.

C The tension of strings on each cuboid is the same

D The tension of string on cuboid W is the greatest.

8 A wire that obeys Hooke's law is of length x_1 when it is in equilibrium under a tension T_1; its length becomes x_2 when the tension is increased to T_2.

What is the extra energy stored in the wire as a result of this process?

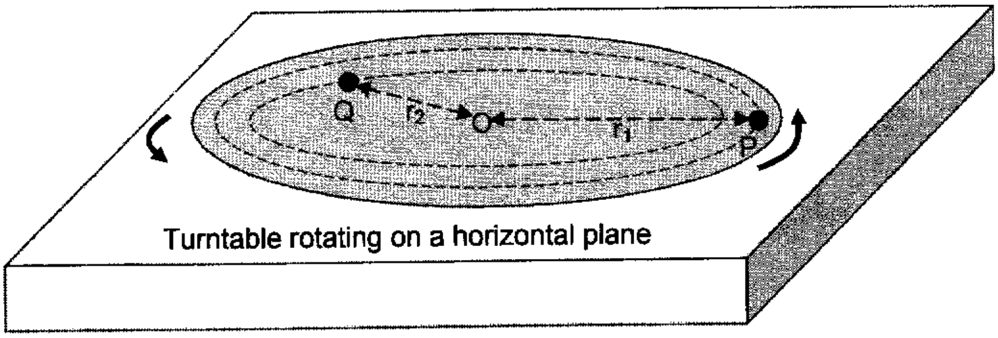
A $\frac{1}{2}(T_2+T_1)(x_2-x_1)$

B $\frac{1}{2}(T_2-T_1)(x_2-x_1)$

C $\frac{1}{2}(T_2+T_1)(x_2+x_1)$

D $\frac{1}{2}(T_2-T_1)(x_2+x_1)$

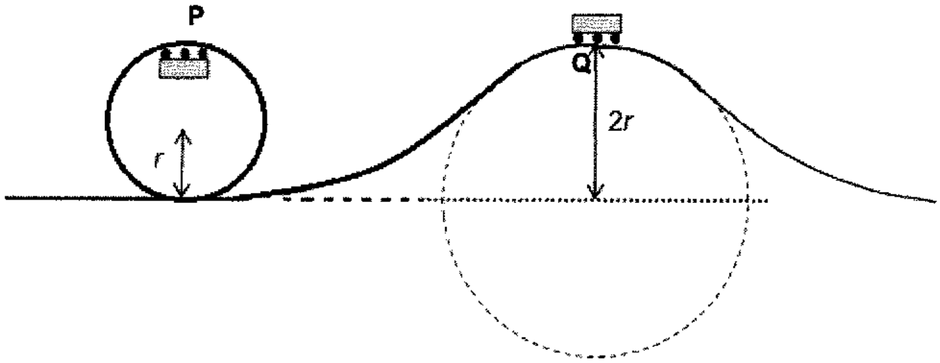
9 A turntable consists of a rotating horizontal disc moving at a fixed rotational speed. Two small objects P and Q with the same mass, are placed on the turntable as shown, where P is at a distance r_1 from the centre O and Q is at a distance r_2 from the centre.



Which of the following correctly relates P and Q's linear speeds and their centripetal forces?

	linear speed	centripetal force
A	same for P and Q	greater for Q
B	same for P and Q	greater for P
C	greater for P	greater for Q
D	greater for P	greater for P

10 A cart of mass m goes round a vertical loop of radius r before racing over a hill of radius of curvature $2r$ as shown in the diagram.



If the cart just remains in contact with the track at the top of the loop at point P, what is the force the cart exerts on the track at the top of the hill at point Q? Assume that resistive forces are negligible.

A 0 **B** $\frac{mg}{2}$ **C** mg **D** $\frac{3mg}{2}$

11 A stationary object is released from a distance $6R$ from the surface of the Earth which has radius R and mass M.

Which one of the following expressions gives the speed of the object on hitting the Earth?

A $\sqrt{\frac{GM}{R}}$ **B** $\sqrt{\frac{GM}{5R}}$ **C** $\sqrt{\frac{12GM}{7R}}$ **D** $\sqrt{\frac{5GM}{3R}}$

12 A spacecraft orbiting a planet in uniform circular motion has an antenna detached gently from it.

Neglecting air resistance, which statement best describes the motion of this detached antenna?

A It will move off in a straight line away from the planet.

B It will take a parabolic path into the planet.

C It will continue to orbit in uniform circular motion.

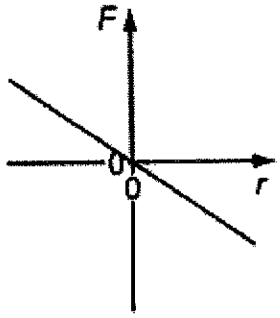
D It will drop straight down into the planet.

13 A rigid container has an ideal gas. The mean square speed of the gas molecules in the container is 3.0×10^5 m^2 s^{-2}. Over a period of time, one quarter of the gas molecules escape from the container. The pressure of the gas in the container is reduced to half.

What is the mean square speed of the molecules left in the container?

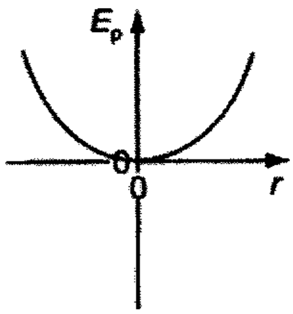
A 1.0×10^5 m^2 s^{-2} **B** 2.0×10^5 m^2 s^{-2} **C** 4.5×10^5 m^2 s^{-2} **D** 9.0×10^5 m^2 s^{-2}

14 A particle is moving such that the force F on it changes with the distance r from a fixed point as shown.

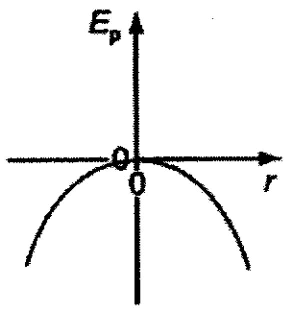


Which graph shows the relationship between the potential energy E_p of the particle and the distance r?

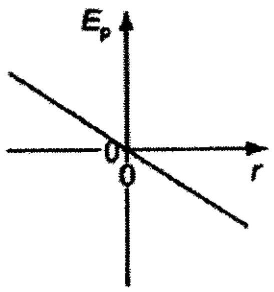
A



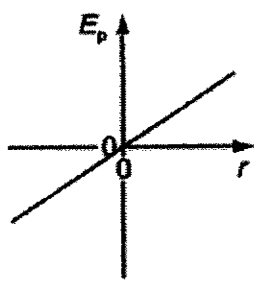
B



C



D



15 An object placed on a horizontal platform is vibrating vertically in simple harmonic motion with a frequency of 3.0 Hz.

The amplitude of vibration of the platform is gradually increased from zero. At one particular amplitude, the object is seen to lose contact with the platform.

What is the amplitude of the oscillation when this occurs?

A 2.8 cm **B** 6.2 cm **C** 7.8 cm **D** 12.4 cm

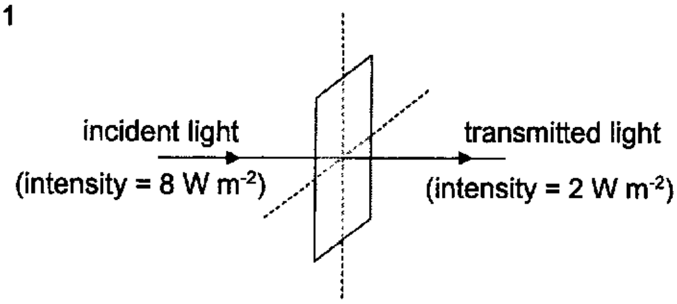
16 A progressive wave of amplitude A has intensity I. This wave combines with another coherent wave of amplitude $0.6A$ at a point P in space. The 2 waves started out anti-phase and arrives at point P with a path difference of 4 wavelengths.

What is the resultant intensity of the combined waves in terms of I at point P?

A $0.16\ I$ **B** $0.4I$ **C** $1.6I$ **D** $2.6I$

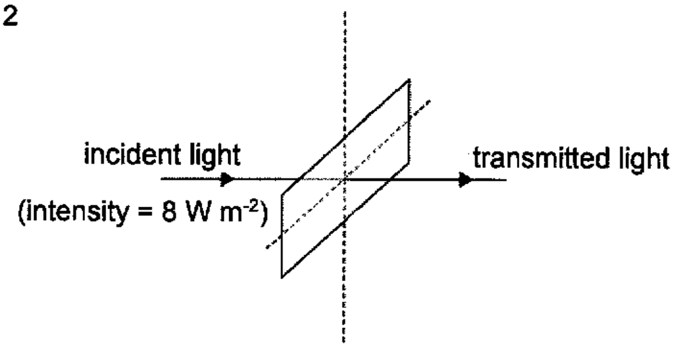
17 Plane-polarized light is incident normally on a polarizer which is able to rotate in the horizontal axis. In the first experiment, after the first rotation, the intensity of the incident light is 8 W m^{-2} and the transmitted intensity of light is 2 W m^{-2}, as shown in diagram 1.

diagram 1



The experiment is repeated with the same incident light but with polarizer rotated 90° from the orientation in diagram 1. This set-up is shown in diagram 2.

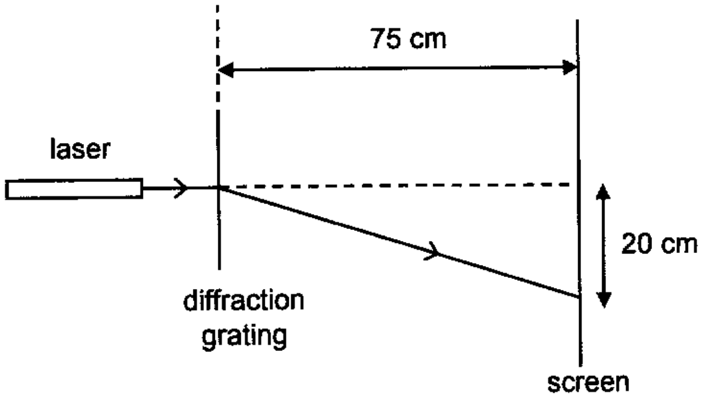
diagram 2



What is the new transmitted intensity?

A 0 W m^{-2} **B** 2 W m^{-2} **C** 6 W m^{-2} **D** 8 W m^{-2}

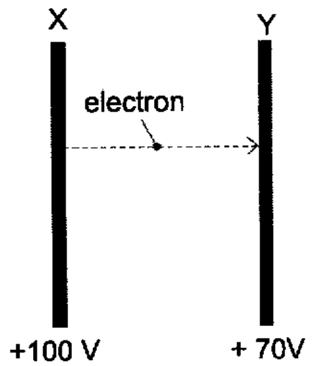
18 A laser is shone through a diffraction grating of 300 lines per mm. The second order fringe appears on a screen 75 cm away from the diffraction grating and 20 cm away from the central fringe.



What is the wavelength of the laser beam?

A 429 nm **B** 444 nm **C** 858 nm **D** 888 nm

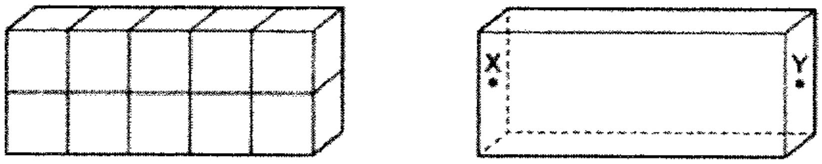
19 Two fixed parallel metal plates X and Y are at constant potentials of +100 V and +70 V respectively. An electron travelling from X to Y experiences a change in potential energy ΔE_p.



Which row shows correctly the direction of the electrostatic force F on the electron and the value of ΔE_p?

	direction of F	ΔE_p
A	towards X	+30 eV
B	towards Y	-30 eV
C	away from X	+30 eV
D	away from Y	-30 eV

20 A metal cube has a resistance of 4.0 Ω between opposite faces. Ten of these cubes are put together to make a cuboid as shown.



There is no extra resistance where the faces of the cubes touch each other.

What is the resistance of the cuboid when connected between faces X and Y?

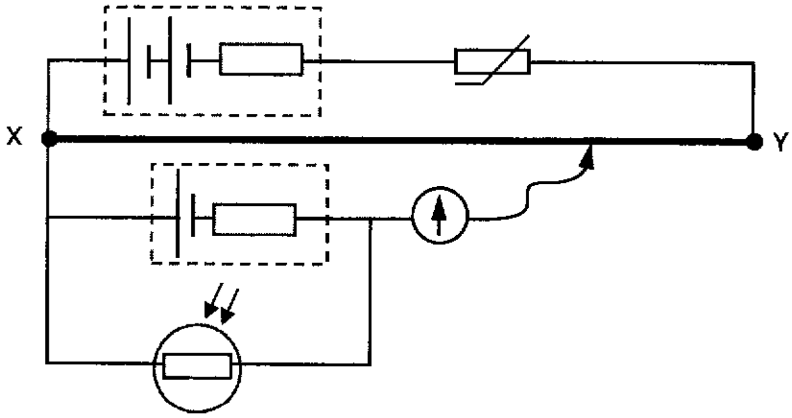
A 1.6 Ω

B 2.0 Ω

C 10 Ω

D 40 Ω

21 An NTC thermistor and a light-dependent resistor are connected in a potentiometer circuit. The batteries have finite internal resistance. XY is a resistance wire.



Which row of conditions will give the largest balance length of the potentiometer?

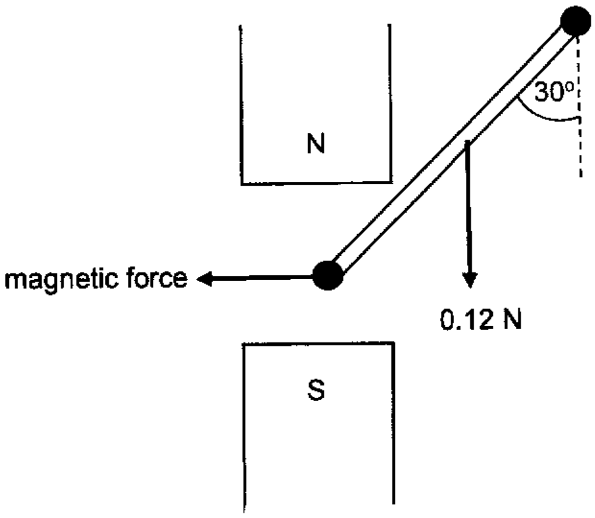
	temperature	lighting condition
A	high	bright
B	high	dark
C	low	bright
D	low	dark

22 A main transformer has a primary coil of 2500 turns and a secondary coil of 130 turns. The primary coil is connected to a main supply where V_{rms} is 230 V. The secondary coil is connected to a lamp of resistance 6.0 Ω. The transformer is 100% efficient.

What is the peak power dissipated by the lamp?

A 12 W **B** 24 W **C** 48 W **D** 96 W

23 A rigid square coil of side 60 mm has 50 turns. It hangs vertically so that it can rotate freely about one side.

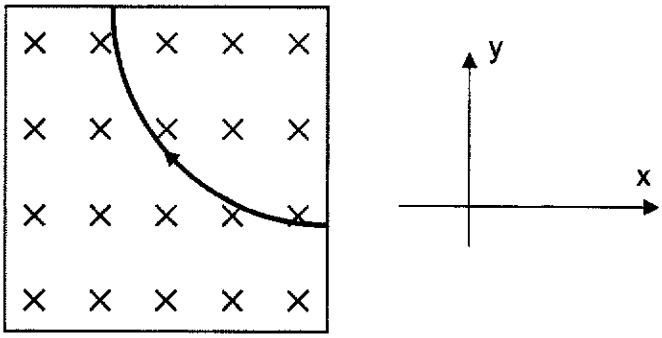


When a current of 0.40 A passes through the coil, it hangs at an angle 30° to the vertical with its lowest side in the vertical magnetic field of a magnet. The weight of the coil is 0.12 N.

What is the magnetic flux density of the field between the magnets?

A 0.029 T **B** 0.058 T **C** 0.087 T **D** 1.4 T

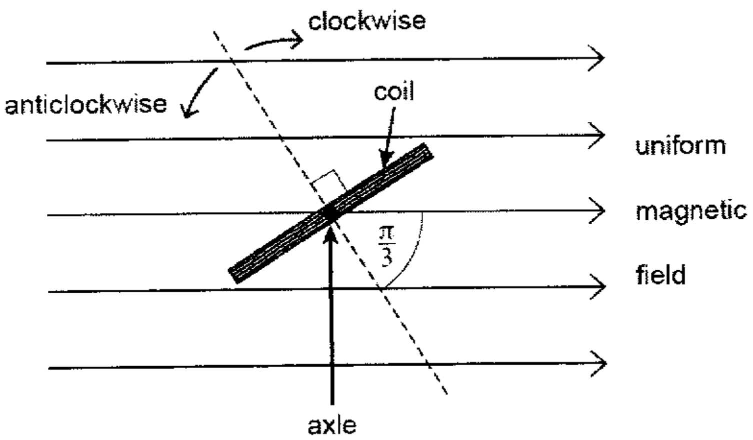
24 A particle travels through a region of uniform magnetic field in a circular path as shown. The magnetic field is directed into the plane of the page.



What is the sign of charge of the particle and the direction electric field to be applied in the same region, for it to pass through with no deflection?

	sign of charge	direction of electric field
A	positive	+y
B	positive	–y
C	negative	+y
D	negative	–y

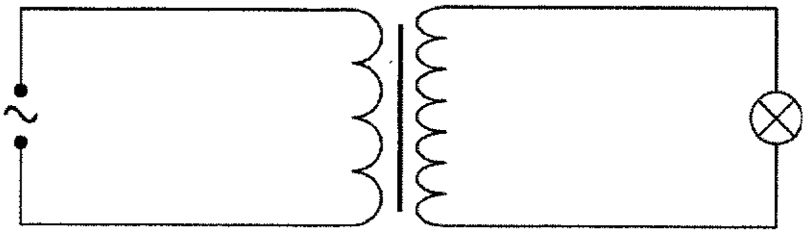
25 The diagram shows a coil placed in a uniform magnetic field. In the position shown, the angle between the normal to the plane of the coil and the magnetic field is $\frac{\pi}{3}$ rad.



Which row shows the angles through which the coil should be rotated, and the direction of rotation, so that the flux linkage and the induced e.m.f. becomes a maximum?

	angle of rotation/ rad	
	for maximum flux linkage	for maximum induced e.m.f.
A	$\frac{\pi}{6}$ clockwise	$\frac{\pi}{3}$ anticlockwise
B	$\frac{\pi}{6}$ anticlockwise	$\frac{\pi}{3}$ clockwise
C	$\frac{\pi}{3}$ clockwise	$\frac{\pi}{6}$ anticlockwise
D	$\frac{\pi}{3}$ anticlockwise	$\frac{\pi}{6}$ clockwise

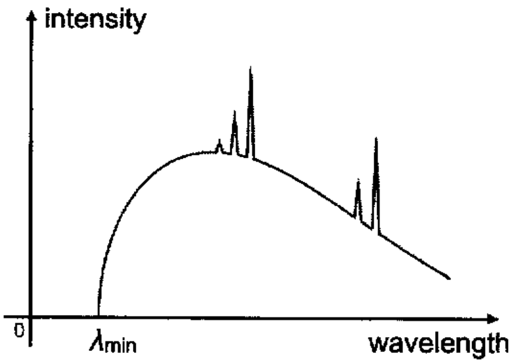
26 The primary coil of a step-up ideal transformer is connected to a source of alternating p.d. The secondary coil is connected to a lamp.



Which row correctly describes the ratios of flux linkages and currents through the secondary coil in relation to the primary coil?

	$\frac{\text{secondary magnetic flux linkage}}{\text{primary magnetic flux linkage}}$	$\frac{\text{secondary current}}{\text{primary current}}$
A	<1	<1
B	>1	<1
C	>1	>1
D	<1	>1

27 An X-ray spectrum is shown in the diagram below.



What does the value of λ_{min} represent?

A The threshold wavelength of the target metal used to produce X-ray.

B The wavelength corresponding to the ionization energy of the target metal.

C The de Broglie wavelength of the electron with maximum energy.

D The wavelength corresponding to all the energy supplied to an electron in the accelerating electric field being converted into a single X-ray photon.

28 What is the de Broglie wavelength of an alpha particle of kinetic energy *E*, given that *u* is the unified atomic mass unit?

A $\dfrac{h}{2\sqrt{uE}}$ **B** $\dfrac{2\sqrt{uE}}{h}$ **C** $\dfrac{h}{2\sqrt{2uE}}$ **D** $\dfrac{2\sqrt{2uE}}{h}$

29 A Geiger counter is placed near a radioactive source and different materials are placed between the source and the Geiger counter.

The results of the tests are shown in the table.

material	count rate of Geiger counter / s^{-1}
none	1000
paper	1000
aluminium foil	250
thick steel	50

What is the radiation emitted by the source?

A α only

B α and γ

C α and β

D β and γ

30 The mass of the fuel in a fission reactor decreases at a rate of 6.0×10^{-6} kg hour^{-1}.

What is the maximum possible power output of the reactor?

A 75 MW

B 150 MW

C 300 MW

D 9000 MW

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2024 H2 Prelim Paper 1 Solutions:

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

1 A

Units of $\Delta P = kgm^{-1}s^{-2}$, units of $\rho = kgm^{-3}$

Units of $\frac{\Delta P}{\rho} = m^2 s^{-2}$, hence n =0.5

2 B

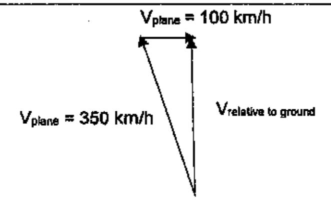
Accurate → How close they are to the true value
Precise → How close the measured readings are from one another

Readings *d*/ mm				Ave Value	Largest – smallest value
1.49	1.46	1.52	1.50	1.4925	0.06
1.48	1.58	1.51	1.40	1.4925	0.18 (not precise)
1.35	1.37	1.42	1.42	1.39	0.07
1.32	1.37	1.41	1.50	1.4	0.18

3 B

$V_{relative\ to\ ground}$

$= \sqrt{350^2 - 100^2}$ = 335 km/h



4 C

5 A

Change in momentum = area under F-t graph

Area under F-t graph from 0 to 10 seconds = 0.5 x (8+4) x 12 + [(-0.5) x (2) x (12)] = 60 N s

Change in momentum = final momentum – initial momentum

60 = mv – 0

v = 200 m s^{-1}

6 A

Force by wall on water = $< F_{net} >$ = *mass per unit time* × Δv

$= \frac{m}{\Delta t}\Delta v = \frac{\rho(Vol)}{\Delta t}\Delta v$ since $m = \rho(Vol)$

$= \rho\pi r^2 v(0 - v)$

$= -\rho\pi r^2 v^2$

$= -1000\pi(2.0\times10^{-2})^2(0.50)^2$

≈ -0.314 N

By Newton's 3rd Law, Force by water on wall = Force by wall on water = 0.314 N

7 D

On each cuboid ;

Volume of water displaced is the same, therefore U is constant for all cuboids of equal volume.

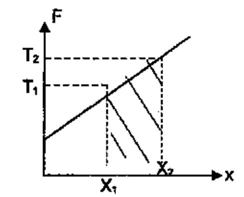
T + U = mg

T +U =ρVg (where ρ is density of material/cubpid)

T = ρVg – U

Since cuboid W has largest density, T on string is the largest.

8 A



Extra energy stored = area of trapezium = $\frac{1}{2}(T_2 + T_1)(x_2 - x_1)$

9 D

Since P and Q have the same angular velocity, the linear speed ($v = r\omega$) of P is greater than Q as $r_1 > r_2$.
Also, centripetal force ($F = mr\omega^2$) is greater for P than Q as $r_1 > r_2$.

10 B

At P: $N + mg = mv^2/r$
$N = mv^2/r - mg$
$v = \sqrt{rg}$ when $N \approx 0$
Since GPE at P and Q is the same, KE at P = KE at Q.

At Q: $mg - N = mv^2/2r$
$N = mg - m(rg)/2r$
$N = mg/2$

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11	D	*By conservation of energy,* $KE_i + GPE_i = KE_f + GPE_f$ $0+\left(-\frac{GMm}{7R}\right) = \frac{1}{2}mv^2 + \left(-\frac{GMm}{R}\right)$ $v=\sqrt{\frac{12GM}{7R}}$
12	C	The antenna will have the same speed as the space-craft and is still bound in orbit. There is still gravitational force acting on it which causes it to move in circular motion.
13	B	$PV=\frac{1}{3}Nm<c^2>$ V and m remain unchanged $\Rightarrow \frac{N<c^2>}{P}$ = constant $\Rightarrow \frac{N\times 3.0\times 10^5}{P} = \frac{\frac{3N}{4}<c^2>}{(P/2)}$ $\Rightarrow$ N = 2.0×10^5 m² s²
14	A	This is an SHM question and the E_p graph is **A**, lowest at the equilibrium and maximum at the amplitudes (opposite from the KE-r graph).
15	A	ma = mg – R Object will remain in contact when R is greater than 0. Object will lose contact when R = 0, ma = mg For SHM, $a = \omega^2 x_o = (2\pi f)^2 x_o = g$ $x_o = \frac{g}{(2\pi f)^2} = \frac{9.81}{(2\pi(2.0))^2} = 9.81/(2\pi(3.0))^2 = 0.028$ m
16	A	$I = kA^2$ Resultant amplitude when antiphase = $A - 0.6A = 0.4A$ Resultant intensity $I_R = k(0.4A)^2 = 0.16kA^2 = 0.16I$

17	C	Using $I = I_o \cos^2\theta$ For diagram 1, $2 = 8\cos^2\theta$ $\Rightarrow \theta = 60°$ For diagram 2, when rotated another 90°, $I = 8\cos^2(90+60)$ = 6 W m⁻²
18	A	$\tan\theta = \frac{20}{75} \Rightarrow \theta = 14.9°$ Using $d\sin\theta = n\lambda$ where $d = \frac{1}{N}$, $\frac{10^{-3}}{300}\sin 14.9° = 2\lambda$ $\Rightarrow \lambda$ = 429 nm
19	A	E field point from high V to low $V \Rightarrow$ E field point towards right Since electron is -vely charged, electric force on electron points towards X or away from Y. Change in EPE from X to Y = $EPE_Y - EPE_X = -eV_Y - (-eV_X) = -70$ eV + 100 eV = +30 eV
20	C	$R = \frac{\rho L}{A} \propto \frac{L}{A}$ $\frac{R'}{R} = \frac{L'}{L} \times \frac{A}{A'}$ $\frac{R'}{4.0} = \frac{5d}{d} \times \frac{d^2}{2d(d)}$ $R' = 10\ \Omega$
21	D	In the driver circuit, the p.d. across XY should be minimized, so the resistance of the NTC thermistor needs to be maximised, according to potential divider rule. Hence, the temperature should be low. The terminal p.d. of the test circuit should be maximised, so the resistance of the LDR needs to be maximised. Hence, the environment should be dark.
22	C	$\frac{V_s}{V_p} = \frac{N_s}{N_p} \Rightarrow V_s = \frac{130}{2500} \times 230 = 12$ V Peak power = $\frac{V_o^2}{R} = \frac{(\sqrt{2}\times 12)^2}{6} = 48$ W

23	**A**	Taking moments about pivot, $F_B \times L\cos 30° = 0.12 \times \frac{L}{2}\sin 30°$ $50B(0.40)(60\times10^{-3})\cos 30° = 0.12 \times \frac{1}{2}\sin 30°$ $B = 0.029$ T
24	**C**	Force causing deflection acts upwards hence magnetic force is upwards. Using Fleming's left hand rule, current is opposite in direction to motion of particle so it must be negatively charged. If direction of magnetic force is upwards, electric force must be downwards so electric field must be upwards
25	**D**	Maximum flux linkage occurs when the B field lines are perpendicular to coil, i.e. either $\frac{\pi}{3}$ anticlockwise. When flux linkage is maximum , induced e.mf. will be minimum (zero) and vice-versa.
26	**B**	Step up transformer ⇒ no. of turns in secondary coil N_s > no. of turns in primary coil N_p Since magnetic flux ϕ in both coil is equal as it is an ideal transformer, $N_s\phi > N_p\phi$ Ideal transformer ⇒ $\frac{I_s}{I_p} = \frac{V_p}{V_s} = \frac{N_p}{N_s} < 1$
27	**D**	
28	**C**	$E = \frac{1}{2} m v^2 = p^2 / 2m$ □ $p = (2mE)^{1/2}$ (m of alpha particle = 4u) $= (8uE)^{1/2}$ $\lambda = h / p = h / (8uE)^{1/2} = h / 2(2uE)^{1/2}$
29	**D**	α will not pass through paper β is stopped by a few cm of aluminium foil only γ can pass through thick steel
30	**B**	$P = \frac{E}{t} = \frac{mc^2}{t}$ $= \frac{(6.0\times10^{-6})(3.00\times10^{8})^2}{60\times60}$ $= 1.5\times10^{8}$ W

BP-675