RAFFLES INSTITUTION
2024 Preliminary Examination

PHYSICS
Higher 2

9749/01

Paper 1 Multiple Choice Questions

25 September 2024
1 hour

Additional Materials: OMR Form

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your index number, name and class on the OMR Form in the spaces provided. Shade the appropriate boxes.

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 OMR Form.

Read the instructions on the OMR Form 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 booklet.
The use of an appropriate scientific calculator is expected, where necessary.

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-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	=	ρgh
gravitational potential	ϕ	=	$-Gm/r$
temperature	T/K	=	$T/°C + 273.15$
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	=	$v_0 \cos \omega t = \pm\omega\sqrt{x_0^2 - x^2}$
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	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\ln 2/t_{1/2}$

1 The speed v of a liquid leaving a tube depends on the difference in pressure ΔP between the ends of the tube and the density ρ of the liquid according to the equation

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

where k is a unitless constant.

What is the value of n?

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

2 A micrometer screw gauge is used to measure the diameters of two cylinders. The measurements of the diameters, with their actual uncertainties, are given as follows:

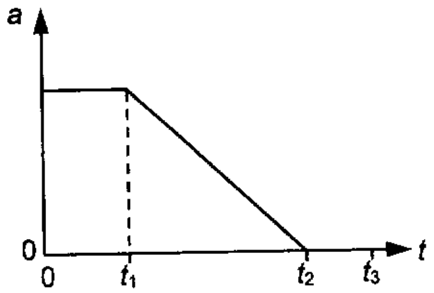
diameter of first cylinder $= (12.78 \pm 0.02)$ mm

diameter of second cylinder $= (16.24 \pm 0.03)$ mm

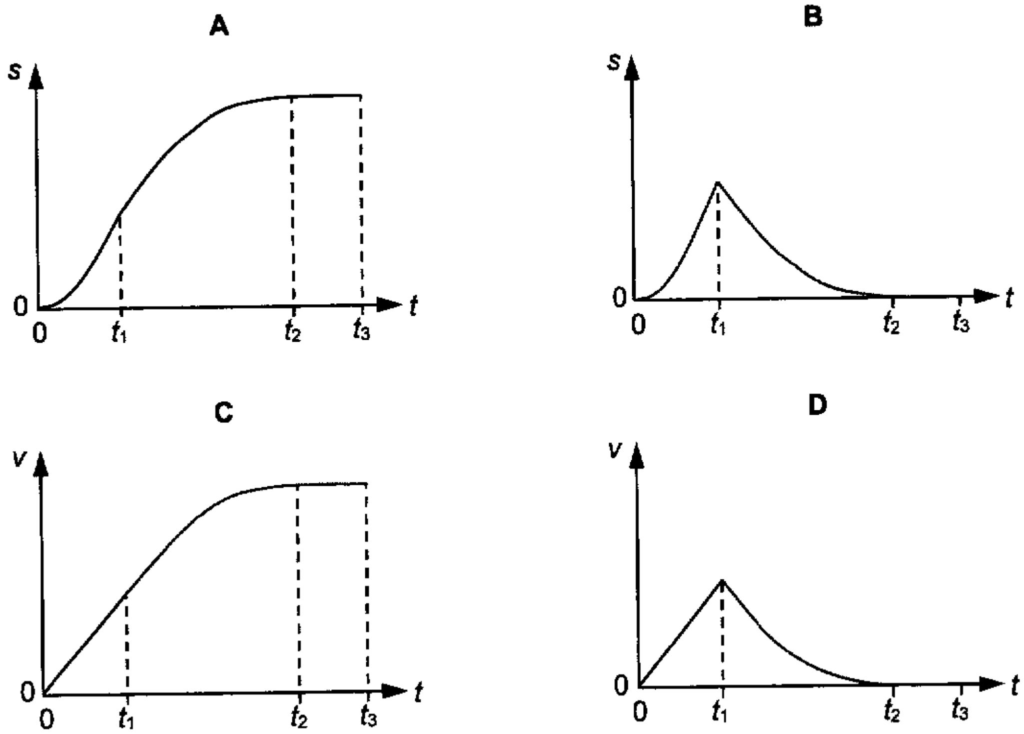
What is the percentage uncertainty in the difference of the two diameters?

A 0.29% **B** 0.58% **C** 0.87% **D** 1.4%

3 A force is applied on a stationary object at time $t = 0$ s. The graph shows how the acceleration a of the object varies with time t.



Which graph shows how the velocity v or displacement s of the object varies with t?



4 A student is standing on a weighing balance inside an ascending lift. The weighing balance gives a reading in newtons.

Which statement about the balance reading is correct?

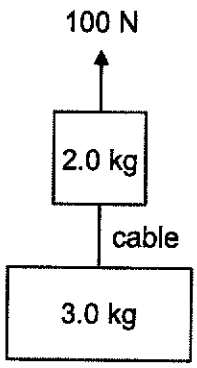
A The reading is less than the student's weight.

B The reading is equal to the student's weight.

C The reading is more than the student's weight.

D The reading can be less than, equal to or more than the student's weight.

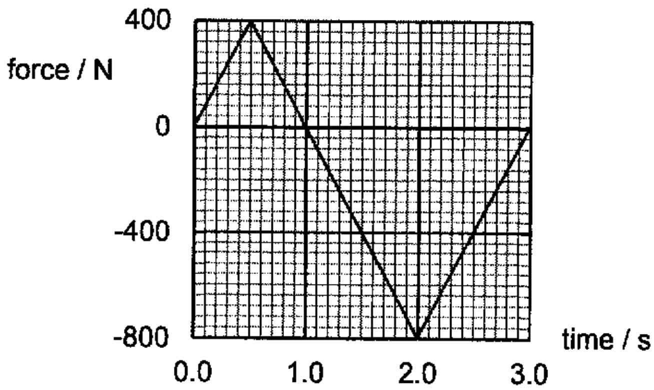
5 Two crates of masses 2.0 kg and 3.0 kg, connected by a cable, are lifted by a force of 100 N.



What is the tension in the cable between the crates?

A 40 N **B** 51 N **C** 60 N **D** 80 N

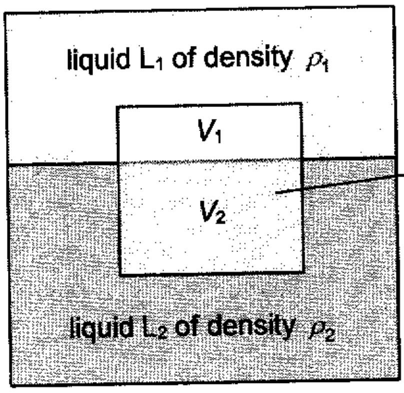
6 A motorcycle of mass 400 kg is travelling at a speed of 4.5 m s^{-1} when it experiences an accelerating force for 1.0 s, followed by a retarding force for 2.0 s as shown.



What is the speed of the motorcycle after 3.0 s?

A 1.5 m s^{-1} **B** 3.0 m s^{-1} **C** 4.5 m s^{-1} **D** 6.0 m s^{-1}

7 A cube of density ρ_c is floating in two liquids L_1 and L_2 of densities ρ_1 and ρ_2 respectively. Volume V_1 of the cube is immersed in L_1, and volume V_2 of the cube is immersed in L_2.

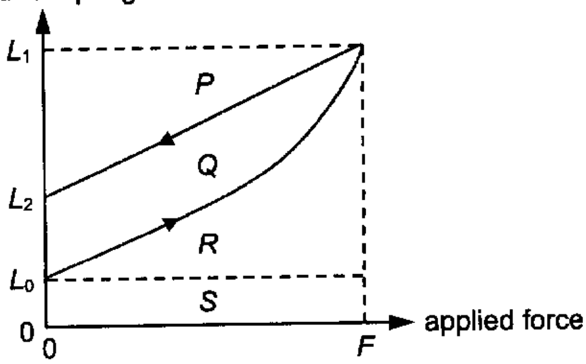


(not drawn to scale)

What is the ratio $\frac{V_1}{V_2}$, if $\rho_2 = 3\rho_1$ and $\rho_c = 2\rho_1$?

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

8 A spring of unstretched length L_0 is extended to length L_1 by an applied force that is increased from zero until F. Upon removal of the force, the spring is damaged and has a new unstretched length L_2. The graph shows the variation of the length of the spring with the applied force.



Which combination of areas give the work done by the force to extend the spring from L_0 to L_1 and which area gives the increase in potential energy of the particles in the spring when its unstretched length is increased from L_0 to L_2?

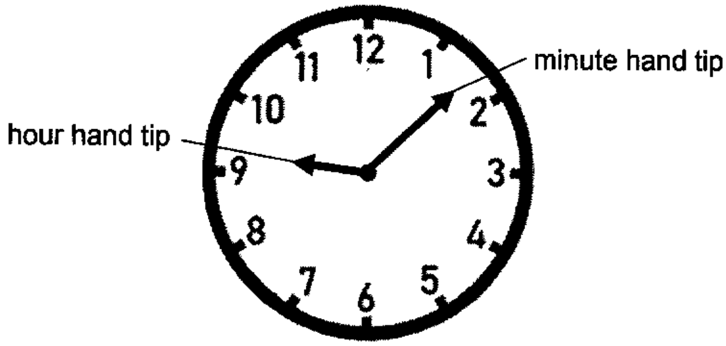
	work done by force from L_0 to L_1	increase in potential energy from L_0 to L_2
A	$P + Q$	Q
B	$R + S$	Q
C	$P + Q$	P
D	$R + S$	P

9 When a car is travelling along a straight road at a constant speed of 72 km h^{-1}, the power delivered by its engine is 12 kW. The efficiency of the engine is 30% and each kilogram of petrol produces 40 MJ of energy.

What is the total resistive force on the car and the mass of petrol required for a one-hour drive?

	total resistive force	mass of petrol
A	170 N	0.32 kg
B	600 N	0.32 kg
C	170 N	3.6 kg
D	600 N	3.6 kg

10 The minute hand on a clock is 1.5 times the length of its hour hand.



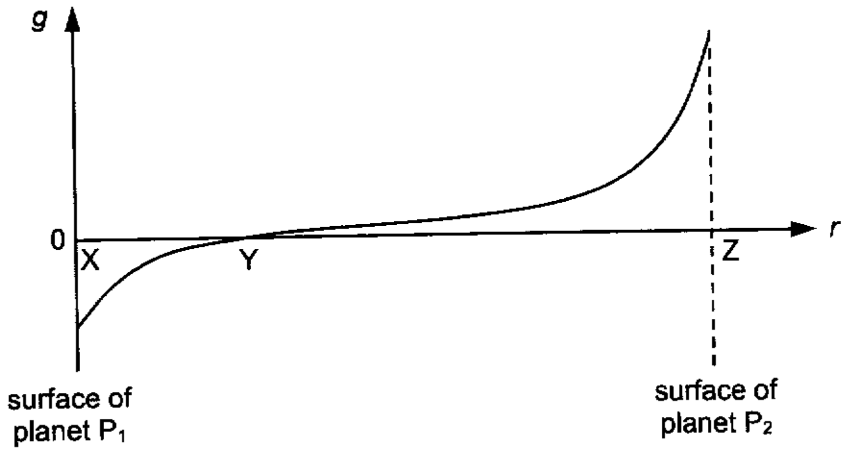
The average tangential speeds of the tips of the minute hand and the hour hand are v_m and v_h respectively.

What is the ratio $\frac{v_m}{v_h}$?

A 0.125 **B** 1.5 **C** 18 **D** 90

11 The graph shows the variation of the gravitational field strength g between the surface of planet P_1 and the surface of planet P_2 with distance r from the surface of planet P_1.

X, Y and Z are points along the line joining the centres of the planets.



Which statement about the gravitational potential between the two planets is correct?

A The gravitational potential at point Y is zero.

B The gravitational potential at point Z is positive.

C The area under the graph gives the value of the change in gravitational potential when a test mass is brought from point X to point Z.

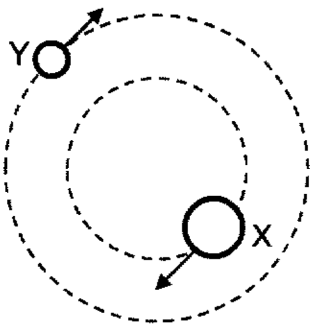
D The gradient of the tangent at any point on the graph gives the value of the gravitational potential at that point.

12 A binary star system consists of two stars X and Y orbiting about a common centre due to their mutual gravitational forces on each other.

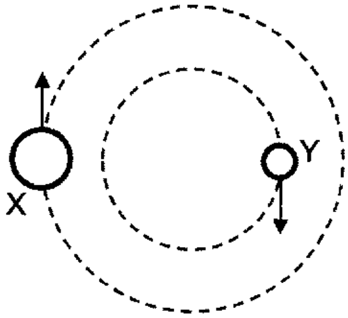
The mass of star X is larger than the mass of star Y.

Which diagram shows the possible positions of stars X and Y and the directions of their velocities?

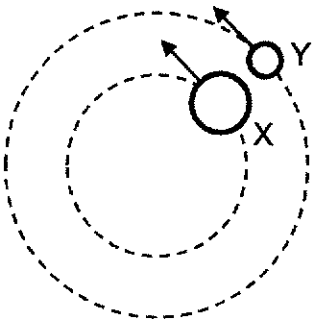
A



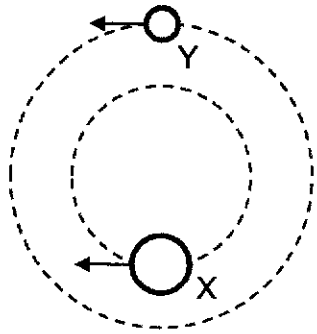
B



C



D



13 Two ideal gases X and Y are separately contained in two identical vessels. The absolute temperature and root-mean-square speed of the molecules of Y are 2 and 3 times that of X respectively.

What is the ratio $\frac{\text{molecular mass of X}}{\text{molecular mass of Y}}$?

A 0.22 **B** 1.5 **C** 2.3 **D** 4.5

14 In the continuous flow method for determining the specific heat capacity of a liquid, it is important to account for heat losses.

If the inlet temperature and room temperature are unchanged, which other quantity must also be kept constant in such experiments?

A electrical power input

B outlet temperature

C rate of liquid flow

D mass of liquid collected

15 A sphere of mass 20 g undergoes simple harmonic motion with a period of 9.0 s. The speed of the sphere 3.0 s after starting from the equilibrium is 4.0 m s^{-1}.

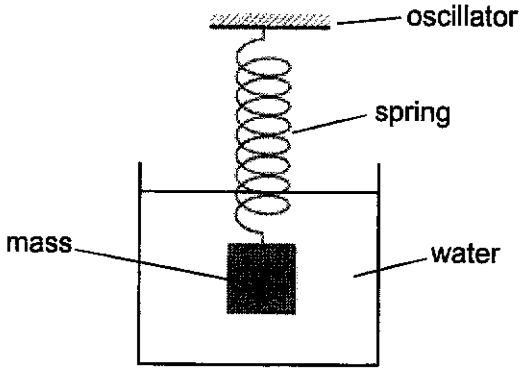
What is the kinetic energy of the sphere when it next passes the equilibrium position?

A 0 J **B** 0.16 J **C** 0.21 J **D** 0.64 J

16 A light spring hangs vertically from a driving oscillator. A mass is attached to the fee end of the spring and is submerged in water as shown.

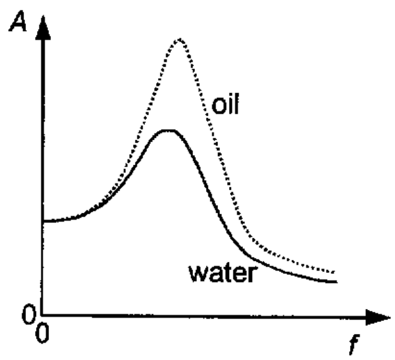
The mass is made to oscillate vertically at various frequencies of the oscillator. The oscillator has a constant amplitude at all frequencies.

The experiment is then repeated with the mass submerged in oil.

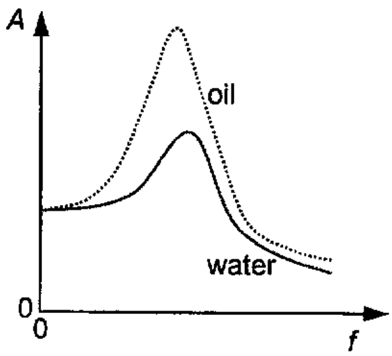


Which graph shows how the amplitude A of the oscillating mass varies with the frequency f at which it is driven when the mass is in water and oil?

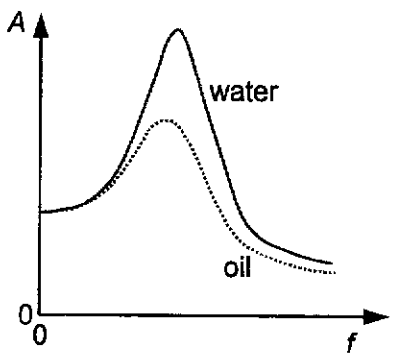
A



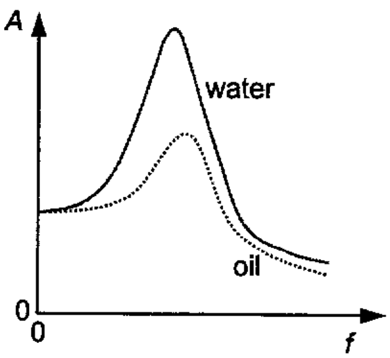
B



C



D



17 Transverse progressive sinusoidal waves of wavelength λ are passing vertically along a horizontal rope. P and Q are points on the rope $\frac{\lambda}{4}$ apart. The direction of energy transfer is from P to Q.

Which of the following describes the displacement and movement of Q at the instant when P is displaced downwards and moving upwards?

	displacement of Q	movement of Q
A	zero	upwards
B	downwards	downwards
C	upwards	downwards
D	upwards	upwards

18 An astronaut observes a point source of light from a distance in space. The diameter of the pupil of his eyes is 5.0 mm. The minimum power of light that a human eye can detect is 2.0×10^{-13} W.

If the power of the light emitted by the source is 10 W, which statement about the distance at which the astronaut can see the light source is correct?

A The astronaut can see the light source at a minimum distance of 8800 m.

B The astronaut can see the light source at a maximum distance of 8800 m.

C The astronaut can see the light source at a minimum distance of 17700 m.

D The astronaut can see the light source at a maximum distance of 17700 m.

19 A pillar in a concert hall can block the view of the audience but it does not disrupt their hearing.

What is the reason for this observation?

A Sound waves have a much longer wavelength compared to light waves.

B Sound waves are longitudinal whereas light waves are transverse.

C Sound travels at a much slower speed compared to light.

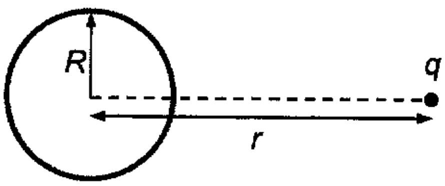
D Sound is a pressure wave whereas light is an electromagnetic wave.

20 Two point sources of light at a fixed distance apart emit monochromatic light of wavelength λ. An observer views the light sources with a telescope of aperture size d at a distance D from the light sources.

Which combination of λ, d and D would give the observer the best setting to resolve the light sources?

	λ	d	D
A	shorter	larger	nearer
B	shorter	smaller	nearer
C	shorter	larger	further
D	longer	smaller	further

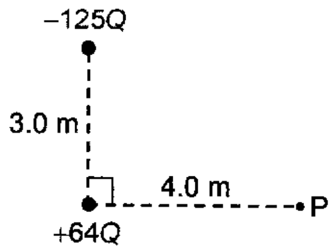
21 A charged conducting sphere of radius R has an electric potential V. A particle of charge q is at a distance r away from the centre of the charged sphere.



What is the magnitude of the electric force acting on the particle due to the charged sphere?

A $\dfrac{qV}{R}$ **B** $\dfrac{qV}{r}$ **C** $\dfrac{qVr}{R^2}$ **D** $\dfrac{qVR}{r^2}$

22 Two charged particles of charges +64Q and −125Q are separated by a distance of 3.0 m. Point P is at a distance 4.0 m to the right of the particle of charge +64Q.



What is the magnitude of the electric field strength at point P?

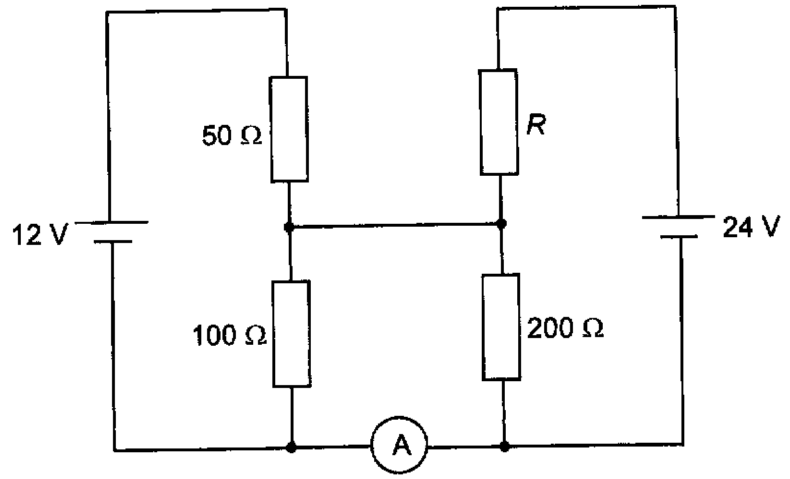
A $\dfrac{Q}{4\pi\varepsilon_0}$ **B** $\dfrac{3Q}{4\pi\varepsilon_0}$ **C** $\dfrac{9Q}{4\pi\varepsilon_0}$ **D** $\dfrac{41Q}{4\pi\varepsilon_0}$

23 Two wires X and Y are of the same length. The resistivity of wire X is half the resistivity of wire Y. The diameter of wire X is one quarter the diameter of wire Y. X and Y are connected in parallel to a battery with negligible internal resistance.

What fraction of the total current passes through wire X?

A $\frac{1}{9}$ **B** $\frac{1}{8}$ **C** $\frac{1}{3}$ **D** $\frac{1}{2}$

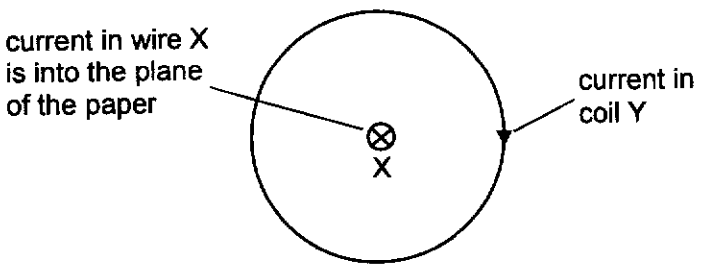
24 In the circuit shown, the ammeter reading is zero.



What is the value of resistance R?

A 40 Ω **B** 100 Ω **C** 200 Ω **D** 400 Ω

25 A long straight wire X is placed along the central axis of a flat circular coil Y. The wire and the coil each carry a current as shown.



Which statement about the force acting on each part of coil Y due to the current in wire X is correct?

A The force is towards wire X.

B The force is away from wire X.

C There is no force in all directions.

D The force is perpendicular to the plane of coil Y.

26 A straight wire of length 15 m is placed horizontally along the East-West direction. The wire is raised vertically through a height of 5.0 m in 150 ms.

The magnetic flux density due to the Earth's magnetic field at this location is 3.0×10^{-5} T at an angle of 50° below the horizontal.

What is the average e.m.f. induced across the ends of the wire?

A 0.0 mV **B** 9.6 mV **C** 11 mV **D** 15 mV

27 A generator produces a r.m.s. current of 50 A at a r.m.s. voltage of 240 V. The voltage is stepped up to 50 kV r.m.s. by an ideal transformer and transmitted through a power line with a total resistance of 100 Ω.

What is the percentage power lost in the transmission?

A 0.048% **B** 0.20% **C** 0.48% **D** 2.0%

28 An electron and a baseball have kinetic energies of 1.0 MeV and 100 J respectively. The percentage uncertainty in the measurement of their momenta is 1.0%.

What is the approximate ratio of the minimum uncertainty in the position of the electron to that of the baseball?

A 10^{7} **B** 10^{14} **C** 10^{22} **D** 10^{44}

29 Which series of radioactive decays will result in the formation of a different isotope of the parent nuclide?

A gamma decay

B one alpha decay and one beta decay

C one alpha decay and two beta decays

D two alpha decays and one beta decay

30 A sample consists of a radioactive nuclide X while another sample consists of a radioactive nuclide Y. After an interval of time, it is found that $\frac{7}{8}$ of the atoms of X and $\frac{3}{4}$ of the atoms of Y have decayed.

What is the ratio $\frac{\text{half life of X}}{\text{half life of Y}}$?

A 0.46 **B** 0.67 **C** 1.5 **D** 2.2

End of Paper 1

Raffles Institution
Year 5-6 Physics Department

2024 H2 Physics Preliminary Examination Solution

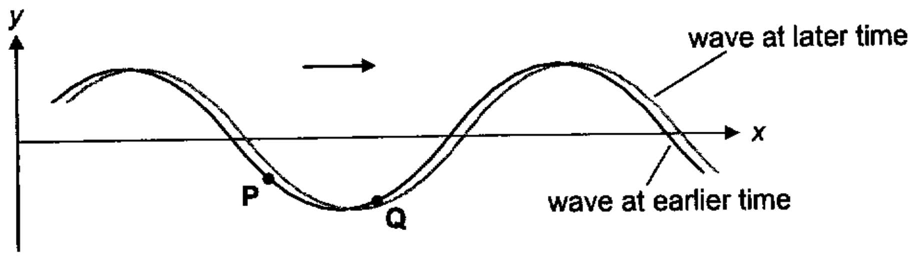
Paper 1

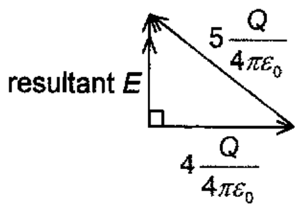
Qn	Ans	Solution
1	A	units of $\Delta P = \frac{\text{kg m s}^{-2}}{\text{m}^2} = \text{kg m}^{-1}\text{ s}^{-2}$ units of $\rho = \text{kg m}^{-3}$ units of $\left(\frac{\Delta P}{\rho}\right)^n = \left(\frac{\text{kg m}^{-1}\text{ s}^{-2}}{\text{kg m}^{-3}}\right)^n = \left(\text{m}^2\text{ s}^{-2}\right)^n$ units of $v = \text{m s}^{-1}$ For equation to be homogeneous, units of $\left(\frac{\Delta P}{\rho}\right)^n$ = units of v $\text{m}^{2n}\text{ s}^{-2n} = \text{m s}^{-1}$ comparing indices of m: $2n = 1 \quad \Rightarrow \quad n = \frac{1}{2}$
2	D	$d = d_2 - d_1 = 16.24 - 12.78 = 3.46$ mm $\Delta d = \Delta d_2 + \Delta d_1 = 0.03 + 0.02 = 0.05$ mm $\frac{\Delta d}{d} \times 100\% = \frac{0.05}{3.46} \times 100\% = 1.4451 = 1.4\%$
3	C	From *a*-*t* graph: From $t = 0$ to $t = t_1$, acceleration is constant which implies that the object's velocity is increasing at a constant rate. From $t = t_1$ to $t = t_2$, acceleration is decreasing which implies that the object's velocity is increasing at a decreasing rate. From $t = t_2$ to $t = t_3$, acceleration is zero which implies that the object's velocity is constant. Since $a = \frac{dv}{dt}$, the gradient of the *v*-*t* graph, which gives acceleration, in Option C follows the description above.
4	D	Option A: Possible, if lift is decelerating / decreasing in speed on its way up. Option B: Possible, if lift is moving upwards at a constant speed. Option C: Possible, if lift is accelerating / increasing in speed on its way up. Option D: Hence, all the options above are possible, depending on the lift's acceleration.

5	C	Applying Newton's second law on the system of both crates, $F_{net,both} = m_{both}a$ $100-(2.0+3.0)(9.81)=(2.0+3.0)\times a$ $a=\dfrac{100-(2.0+3.0)(9.81)}{(2.0+3.0)}=10.19\text{ m s}^{-2}$ Applying Newton's second law on the 2.0 kg crate, $F_{net,2kg} = m_{2kg}a$ $100-2.0(9.81)-T=2.0(10.19)$ $T=60\text{ N}$ OR $F_{net,3kg} = m_{3kg}a$ $T-3.0(9.81)=3.0(10.19)$ $T=60\text{ N}$
6	B	Motorcycle travels in the same direction during the whole duration. Impulse or the change in momentum is the area under the force-time graph. $\Delta p=\int F dt$ $(400)(v-4.5)=\tfrac{1}{2}(1.0)(400)-\tfrac{1}{2}(2.0)(800)$ $v-4.5=-1.5$ $v=4.5-1.5=3.0\text{ m s}^{-1}$
7	D	Since cube is floating, there is vertical equilibrium. $U_1+U_2=W_{cube}$ $V_1\rho_1 g+V_2\rho_2 g=(V_1+V_2)\rho_c g$ $V_1\rho_1+V_2(3\rho_1)=(V_1+V_2)(2\rho_1)$ $3V_2-2V_2=2V_1-V_1$ $V_2=V_1$ $\dfrac{V_1}{V_2}=1$
8	A	Work done by the force to extend the spring is given by the area under force-extension graph i.e. the area bounded by the graph and the vertical axis of the graph given. This work done goes to increase the potential energy of the spring. The potential energy represented by area *P* is released upon the removal of the force. The potential energy represented by area Q is retained in the spring that is permanently stretched i.e. the energy used to separate the particles of the spring further apart.

BP-299

9	D	At constant speed, engine force = resistive force rate at which energy is delivered = rate at which energy is dissipated $P = Fv$ $12\times10^3 = F\left(\frac{72\times10^3}{60\times60}\right)$ $F = 600$ N $E_{\text{from fuel}} = E_{\text{to car}}$ $(0.30)(40\times10^6)(m) = (12\times10^3)(1\times60\times60)$ $m = 3.6$ kg
10	C	The minute hand takes 1 hour to go round the clock once. $\omega_m = \frac{2\pi}{60\times60}$ rad s^{-1} The hour hand takes 12 hours to go round the clock once. $\omega_h = \frac{2\pi}{12\times60\times60}$ rad s^{-1} $\frac{v_m}{v_h} = \frac{r_m\omega_m}{r_h\omega_h} = \left(\frac{1.5r_h}{r_h}\right)\left(\frac{12\times60\times60}{60\times60}\right) = 18$
11	C	Option C (correct): $g = -\frac{d\phi}{dr} \quad \Rightarrow \quad d\phi = -\int g\,dr$ Hence, the area under the *g-r* graph gives the change in the gravitational potential ϕ. Options A and B (incorrect): The total gravitational potential between the two planets is always negative. Gravitational potential is zero only at infinity. Option D (incorrect): The gradient of the graph does not give any meaningful quantity.
12	A	The gravitational force on each star provides the centripetal force for the star to orbit about the common centre of mass of the system. For two stars, mass *M* and *m*, at a distance *d* apart, $\frac{GMm}{d^2} = mr\omega^2 = MR\omega^2$ $mr\omega^2 = MR\omega^2$ $mr = MR$ *R* and *r* are the orbital radii of the stars of masses *M* and *m* respectively. The gravitational force on each star is always directed towards the common centre of mass of the system as the stars orbit. Hence the stars should be on opposite sides of their orbital path, lying along the same straight line through the common centre between them. To maintain this, the stars must also have the same angular velocity ω. Hence star X having a larger mass should have a smaller orbital radius.

13	**D**	From $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT \Rightarrow m = \frac{3kT}{c_{rms}^2} \Rightarrow m \propto \frac{T}{c_{rms}^2}$ $\frac{m_X}{m_Y} = \frac{T_x}{T_y}\left(\frac{c_{rms,Y}}{c_{rms,X}}\right)^2 = \left(\frac{T_x}{2T_x}\right)\left(\frac{3c_{rms,X}}{c_{rms,X}}\right)^2 = \frac{9}{2} = 4.5$
14	**B**	Both the inlet and outlet temperatures and the room temperature must be kept the same so that the rate of heat loss to the surrounding is kept constant for both experiments and can be eliminated.
15	**D**	$v = v_0 \cos\omega t$ $4.0 = v_0 \cos\left(\frac{2\pi}{9.0}\times 3.0\right)$ $v_0 = -8.0 \text{ m s}^{-1}$ $E_K = \frac{1}{2}\times 0.020 \times (-8.0)^2 = 0.64 \text{ J}$
16	**C**	Oil is more viscous than water hence has a greater damping effect on the oscillating mass compared to water. With greater damping, the frequency response curve when the mass is in oil will have smaller amplitudes at all frequencies and the frequency at which resonance occurs will be smaller.
17	**B**	
18	**B**	For astronaut to see the light sources, $P_{received} = \frac{P_{source}}{4\pi r^2}\times A_{pupil} \geq P_{min}$ $r \leq \sqrt{\frac{P_{source}A_{pupil}}{4\pi P_{min}}} = \sqrt{\frac{10\pi(0.0050/2)^2}{4\pi(2.0\times10^{-13})}} = 8838.8 \text{ m}$ $r_{max} = 8800 \text{ m}$
19	**A**	Diffraction is pronounced when the wavelength of the wave is comparable to the width of the obstacle. Sound waves with a longer wavelength than the diameter of the pillar can bend around the pillar. Light waves with a much shorter wavelength than the diameter of the pillar cannot bend around the pillar.

20	**A**	For light sources to be resolved, angle of separation of the 2 sources ≥ minimum angle of separation by Rayleigh criterion $\theta \geq \theta_{\text{min}}$ $\frac{S}{D} \geq \frac{\lambda}{d}$ where S is the distance between the 2 sources $S \geq \frac{\lambda D}{d}$ The best combination is the one that can resolve the smallest distance S between the two sources i.e. shorter λ and D and larger d.
21	**D**	Charge of sphere is Q. $V = \frac{Q}{4\pi\varepsilon_0 R} \quad \Rightarrow \quad Q = 4\pi\varepsilon_0 RV$ $F = \frac{Qq}{4\pi\varepsilon_0 r^2} = \frac{4\pi\varepsilon_0 RVq}{4\pi\varepsilon_0 r^2} = \frac{qVR}{r^2}$
22	**B**	magnitude of E at P due to $+64Q$ $= \frac{64Q}{4\pi\varepsilon_0 (4.0)^2} = 4\frac{Q}{4\pi\varepsilon_0}$  magnitude of E at P due to $-125Q$ $= \frac{125Q}{4\pi\varepsilon_0 (5.0)^2} = 5\frac{Q}{4\pi\varepsilon_0}$ These two E vectors form a right-angle triangle, with the resultant E pointing upwards with magnitude $\sqrt{\left(5\frac{Q}{4\pi\varepsilon_0}\right)^2 - \left(4\frac{Q}{4\pi\varepsilon_0}\right)^2} = 3\frac{Q}{4\pi\varepsilon_0}$.
23	**A**	$I = \frac{E}{R} = \frac{E}{\frac{\rho L}{A}} = \frac{EA}{\rho L} = \frac{E\pi (d/2)^2}{\rho L} = \frac{\pi d^2 E}{4\rho L}$ Hence $I \propto \frac{d^2}{\rho}$ since L and E across the wires in parallel are constants. $\frac{I_X}{I_Y} = \frac{{d_X}^2}{\rho_X} \times \frac{\rho_Y}{{d_Y}^2} = \frac{\left(\frac{1}{4}d_Y\right)^2 \times \rho_Y}{{d_Y}^2 \times \frac{1}{2}\rho_Y} = \frac{2}{16} = \frac{1}{8}$ $\frac{I_X}{I_{total}} = \frac{1}{9}$

24	**D**	Since ammeter reading is zero, there is also no current in the middle wire joining the circuits on the left and right. There is no potential difference between the two ends of this wire and there is no current exchange between the two circuits. 50 Ω and 100 Ω resistors are in series. R and 200 Ω resistors are in series. Potential difference across the 100 Ω and 200 Ω resistors is the same. $V_R = 24 - V_{200}$ $V_R = 24 - V_{100}$ $\frac{R}{R+200} \times 24 = 24 - \frac{100}{100+50} \times 12$ $\frac{R}{R+200} \times 24 = 16$ $R = 400\ \Omega$
25	**C**	The current in X produces a magnetic field along the circumference of coil Y in the clockwise direction. This magnetic field produced is parallel to the current in each part of coil Y, hence there is no magnetic force induced on coil Y in all directions.
26	**B**	As the wire is raised vertically, it cuts the horizontal component of the Earth's magnetic flux density. $E = B_H L v$ $= (B\cos 50°) L \left(\frac{d}{t}\right)$ $= (3.0\times10^{-5})\cos 50° \times 15 \times \frac{5.0}{150\times10^{-3}}$ $= 0.0096418\ \text{V}$ $= 9.6\ \text{mV}$
27	**A**	For an ideal transformer, $I_p V_p = I_s V_s$ $I_s = \frac{I_p V_p}{V_s}$ $= \frac{50\times240}{50\times10^3}$ $= 0.24\ \text{A}$ % power loss $= \frac{P_{loss}}{P_{supplied}}$ $= \frac{I_s^2 R}{I_p V_p}$ $= \frac{0.24^2(100)}{50(240)} \times 100\%$ $= 0.048\%$

28	C	Momentum of particle, $p=\sqrt{2mE}$ Uncertainty in momentum, $\Delta p=0.010\sqrt{2mE}$ Minimum uncertainty in position, $\Delta x=\frac{h}{\Delta p}=\frac{h}{0.010\sqrt{2mE}} \quad \Rightarrow \quad \Delta x \propto \frac{1}{\sqrt{mE}}$ $\frac{\Delta x_{electron}}{\Delta x_{baseball}}=\sqrt{\frac{m_{baseball}E_{baseball}}{m_{electron}E_{electron}}}=\sqrt{\frac{0.150\times100}{(9.11\times10^{-31})(1.0\times10^{6}\times1.60\times10^{-19})}}=1.01\times10^{22}$ Order of magnitude: 10^{22} Note: The mass of the electron is in the data sheet. The mass of the baseball needs to be estimated to the correct order of magnitude.
29	C	An isotope of the parent nuclide will have the same number of protons but different number of neutrons. Hence the <u>atomic number of the isotope is the same</u> as the parent nuclide while its <u>mass number is different</u> after the decays. alpha particle – ${}^{4}_{2}He^{2+}$, beta particle – ${}^{0}_{-1}e$, gamma particle – massless, no charge Option C (correct): One alpha decay – mass number decreases by 4, atomic number decreases by 2 Two beta decays – mass number remains the same, atomic number increases by 2 Overall – daughter nuclide <u>mass number decreases</u> by 4, <u>atomic number remains the same</u> Option A (incorrect): The release of a gamma photon does not affect the atomic and mass numbers. Option B (incorrect): One alpha decay – mass number decreases by 4, atomic number decreases by 2 One beta decay – mass number remains the same, atomic number increases by 1 Overall – daughter nuclide mass number decreases by 4, atomic number decreases by 1 Option D (incorrect): Two alpha decays – mass number decreases by 8, atomic number decreases by 4 One beta decay – mass number remains the same, atomic number increases by 1 Overall – daughter nuclide mass number decreases by 8, atomic number decreases by 3
30	B	For X: $\left(\frac{1}{2}\right)^{\frac{t}{T_X}}=\frac{1}{8} \quad \Rightarrow \quad \frac{t}{T_X}=\frac{\lg(1/8)}{\lg(1/2)}=3 \quad \Rightarrow \quad T_X=\frac{t}{3}$ For Y: $\left(\frac{1}{2}\right)^{\frac{t}{T_Y}}=\frac{1}{4} \quad \Rightarrow \quad \frac{t}{T_Y}=\frac{\lg(1/4)}{\lg(1/2)}=2 \quad \Rightarrow \quad T_Y=\frac{t}{2}$ $\frac{T_X}{T_Y}=\frac{2}{3}=0.66667=0.67$