EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2021
General Certificate of Education Advanced Level
Higher 2

PHYSICS

9749/01

Paper 1 Multiple Choice

22 September 2021

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use paper clips, glue or correction fluid.
Write your name, civics group and registration number on the Answer Sheet in the spaces provided.

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 Answer Sheet.

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

This document consists of **18** printed pages and **0** blank page.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	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,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
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.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_o \cos \omega t$
	$= \pm \omega\sqrt{(x_o^2 - x^2)}$
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,	$x = x_o \sin \omega t$
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,	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 A byte (b) comprises 8 bits.

How many bits are there in 2 terabytes (2Tb)?

A 2×10^9 **B** 16×10^9 **C** 2×10^{12} **D** 16×10^{12}

2 The speed v of waves on a stretched wire is given by the equation

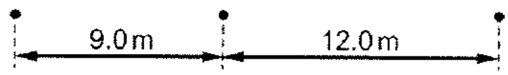
$$v = T^p \mu^q$$

where T is the tension in the wire and μ is the mass per unit length of the wire.

What are the values of p and q?

	p	q
A	$-\frac{1}{2}$	$-\frac{1}{2}$
B	$-\frac{1}{2}$	$\frac{1}{2}$
C	$\frac{1}{2}$	$-\frac{1}{2}$
D	$\frac{1}{2}$	$\frac{1}{2}$

3 A car moves to the right with uniform acceleration along a straight road. Oil leaks from the car at the rate of one drop every three seconds. The diagram shows the distances between three successive oil drops on the road.



What is the acceleration of the car?

A $0.33\,\text{m s}^{-2}$

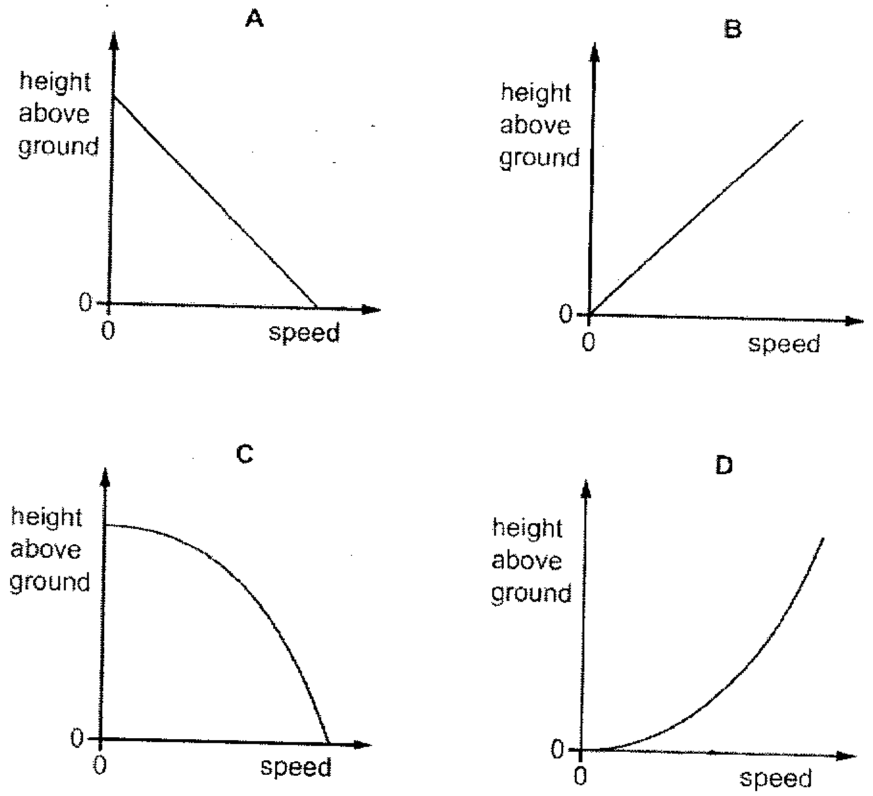
B $0.66\,\text{m s}^{-2}$

C $1.2\,\text{m s}^{-2}$

D $2.0\,\text{m s}^{-2}$

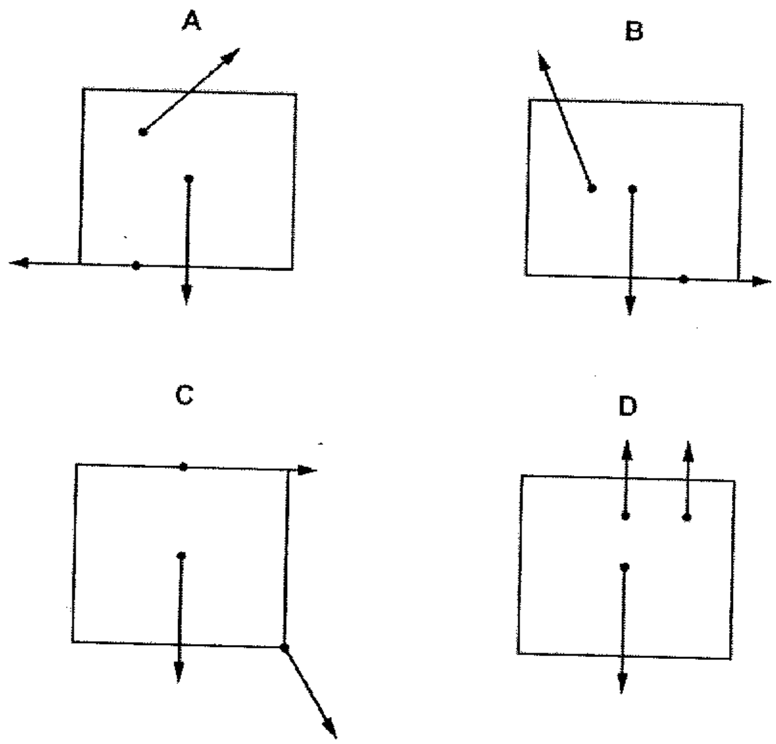
4 A ball is dropped from rest and falls towards the ground. Air resistance is negligible.

Which graph shows the variation with speed of the height of the ball above the ground?



5 Three coplanar forces act on a block.

Which diagram shows the directions of the forces such that the block could be in equilibrium?



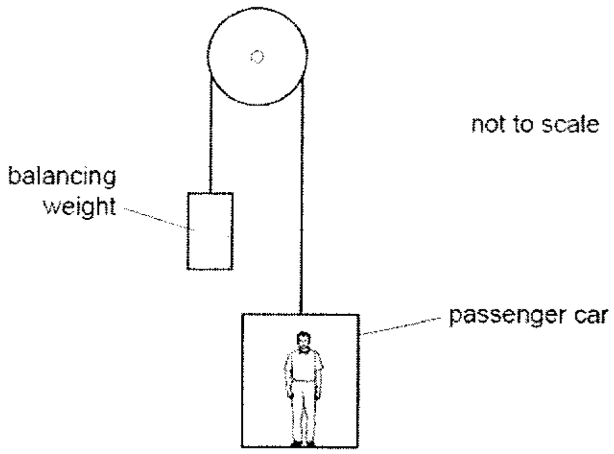
6 Liquid Q has twice the density of liquid R.

At depth x in liquid R, the pressure due to the liquid is 4 kPa.

At which depth in liquid Q is the pressure due to the liquid 9 kPa?

A $\frac{8x}{9}$ **B** $\frac{9x}{8}$ **C** $2x$ **D** $\frac{18x}{4}$

7 A lift consisting of a passenger car supported by a cable runs over a light, frictionless pulley to a balancing weight. The balancing weight falls as the passenger car rises.



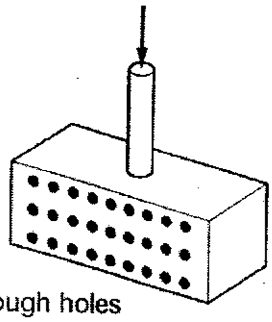
Some masses are shown in the table.

	mass/ kg
Passenger car	520
Balancing weight	800
passenger	80

What is the magnitude of the acceleration of the car when carrying just one passenger and when the pulley is free to rotate?

A 0.14 m s^{-2} **B** 1.4 m s^{-2} **C** 8.0 m s^{-2} **D** 9.8 m s^{-2}

8 A device for spraying paint consists of a box with its axes horizontal and vertical. One of its vertical faces contains small holes. Paint is fed into the box under pressure via a vertical tube and exits through the holes as fine streams moving horizontally.

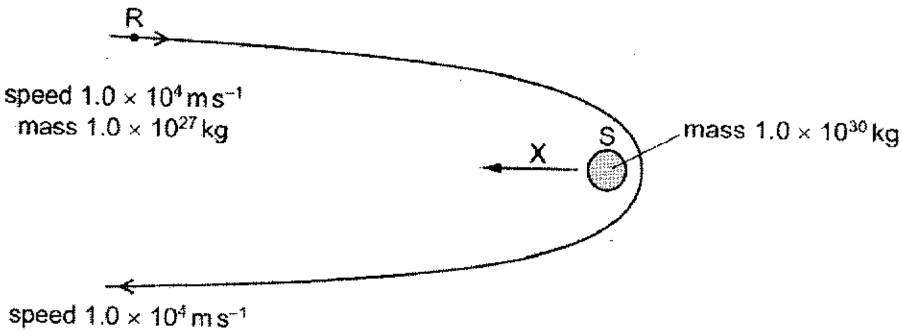


The paint is ejected at a speed of 3.0 m s^{-1} through 27 holes, each of area 0.4 mm^2. The density of the paint is 900 kg m^{-3}.

What is the horizontal force required to hold the device stationary as it ejects the paint?

A 21 mN **B** 29 mN **C** 44 mN **D** 87 mN

9 A rock R of mass 1.0×10^{27} kg is at a large distance from a star S and is travelling at a speed of 1.0×10^4 m s^{-1}. The star has mass 1.0×10^{30} kg. The rock travels around the star on the path shown so that it reverses its direction of motion and, when finally at a large distance from the star again, has the same speed as initially.



Which statement is correct?

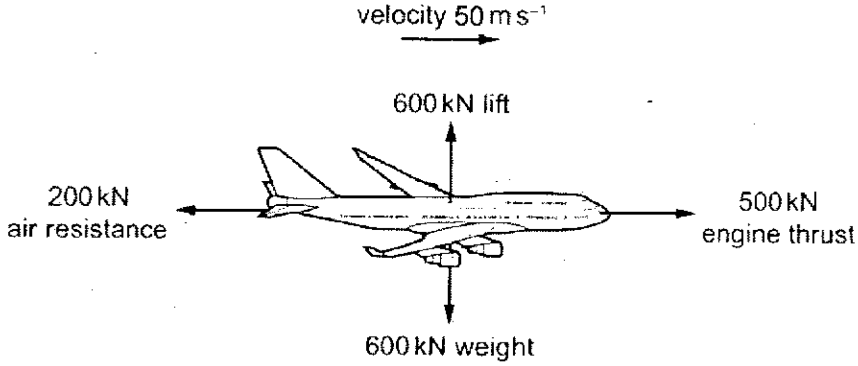
A The change in the momentum of S is in the direction of arrow X.

B The change in the velocity of S is approximately 20 m s^{-1}.

C The magnitude of the change of momentum of R is 10^3 times greater than the magnitude of the change of momentum of S.

D The momentum of R does not change.

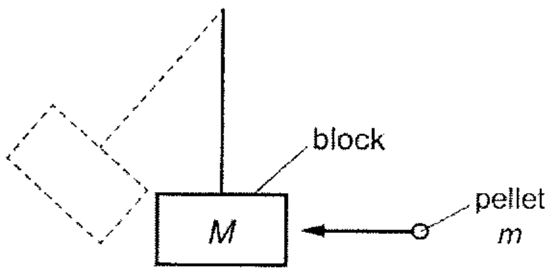
10 The force diagram shows an aircraft accelerating. At the instant shown, the velocity of the aircraft is 50 m s^{-1}.



At which rate is its kinetic energy increasing?

A 2.4 MW **B** 12 MW **C** 15 MW **D** 25 MW

11 The diagram shows a 'ballistic pendulum'.



A pellet of mass m travelling at a speed u hits a stationary block of mass M. The pellet becomes embedded in the block and causes the block to move immediately after the impact.

What is the maximum height gained by the block after impact?

A $\frac{1}{2g}mu^2$

B $\frac{1}{2g}(M+m)u^2$

C $\frac{1}{2g}\left(\frac{m}{M+m}\right)u^2$

D $\frac{1}{2g}\left(\frac{mu}{M+m}\right)^2$

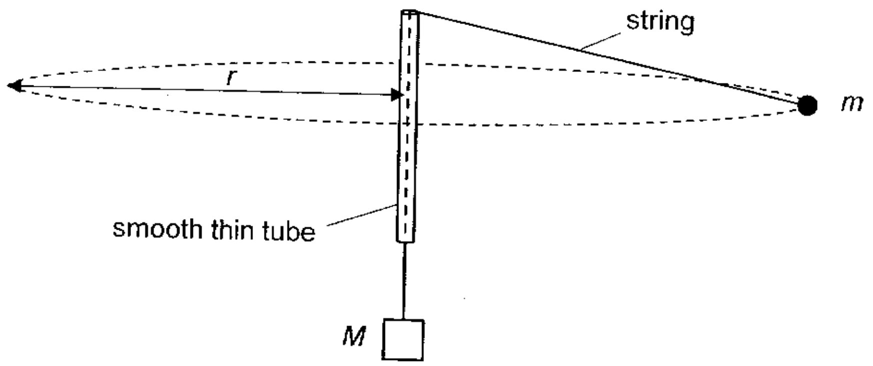
12 A hydroelectric power station uses the gravitational potential energy of water to generate electrical energy.

In one particular power station, the mass of water flowing per unit time is 1.5×10^5 kg s^{-1}. The water falls through a vertical height of 140 m.

The electrical power generated is 100 MW. What is the efficiency of the power station?

A 5.6% **B** 4.3% **C** 49% **D** 77%

13 A string passes through a smooth thin tube, with objects of masses m and M attached to its ends. The tube is swung so that the object with mass m travels in a horizontal circle of constant radius r at constant speed v as shown.



Which of the following expressions is equal to M?

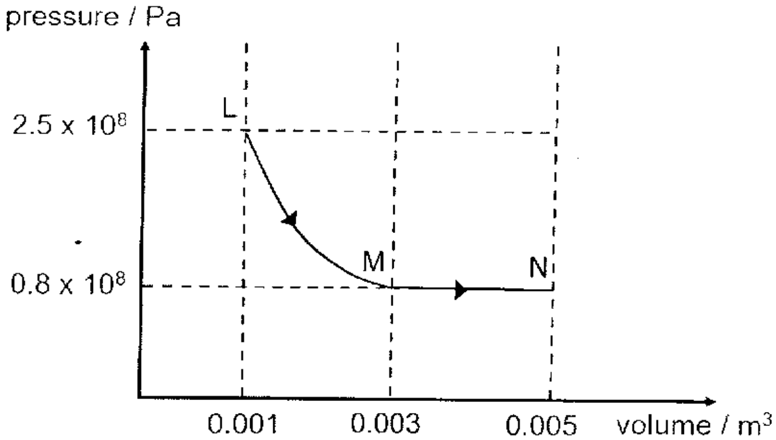
A $m\sqrt{1+\left(\frac{v^2}{rg}\right)^2}$ **B** $\frac{mv^2r}{g}$ **C** $\frac{mv^2g}{r}$ **D** $\frac{mv^2}{rg}$

14 Two isolated planets A and B have masses M_A and M_B respectively. Their centres are a distance D apart and they rotate with a uniform angular velocity ω about an axis which is perpendicular to the line joining their centres.

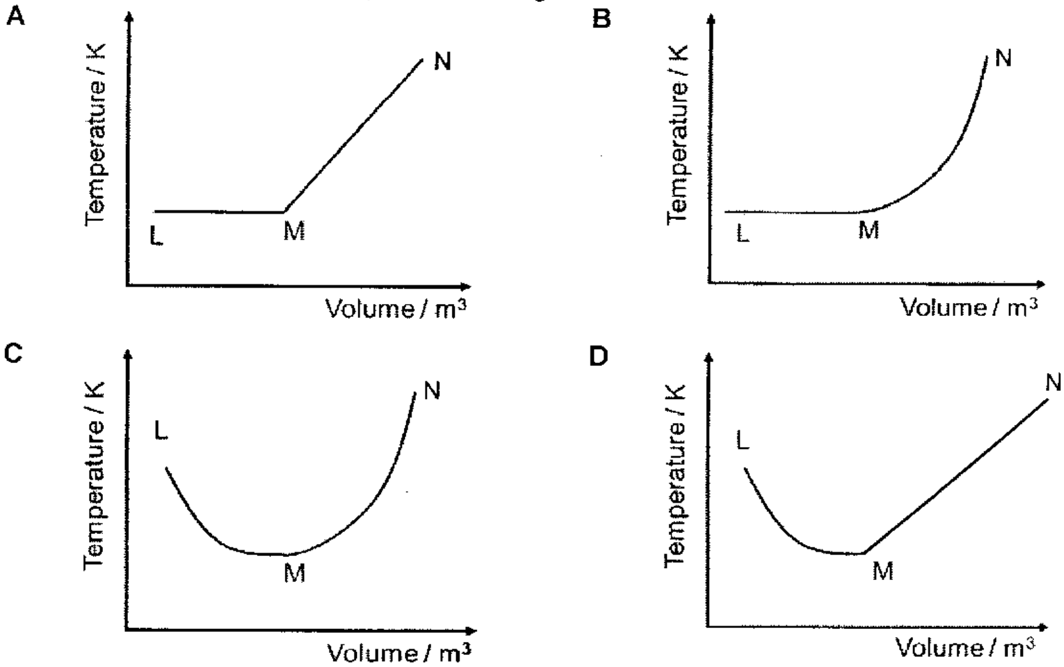
If the distance of planet A from the axis of rotation is R, which of the following does not give the expression for the centripetal force on planet B?

A $\dfrac{GM_AM_B}{D^2}$ **B** $\dfrac{GM_AM_B}{(D-R)^2}$ **C** $M_AR\omega^2$ **D** $M_B(D-R)\omega^2$

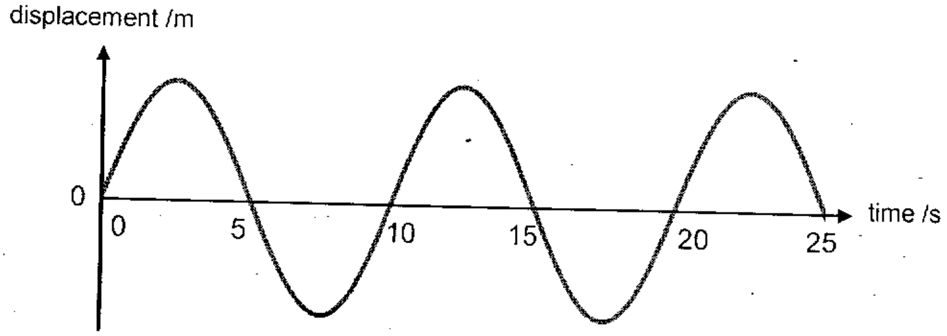
15 A fixed mass of ideal gas undergoes changes of pressure and volume starting at L and ending at N, as shown.



Which graph shows how temperature changes with volume?

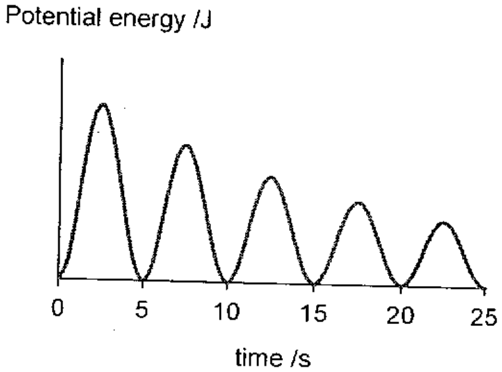


16 The diagram below shows the displacement-time graph for a system oscillating freely with negligible damping.

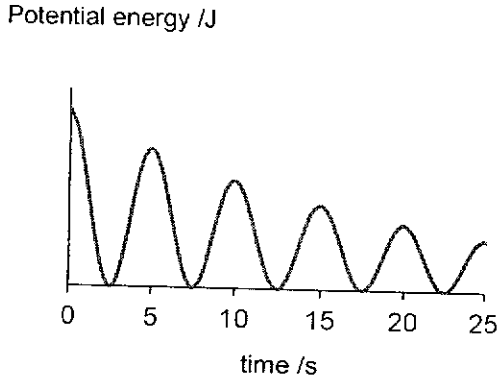


The system is **now** placed in an environment with **significant** damping and set into oscillation. At time t = 0 s, the displacement of the object is 0 m. Which one of the following graphs best describes how the potential energy of the system varies with time?

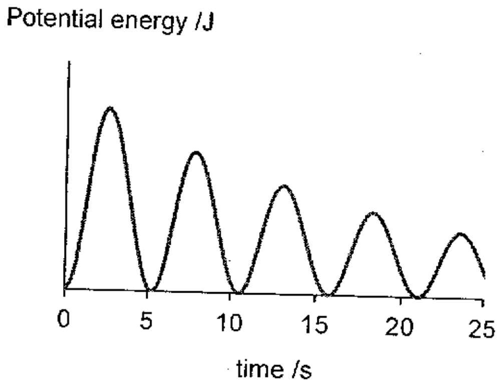
A



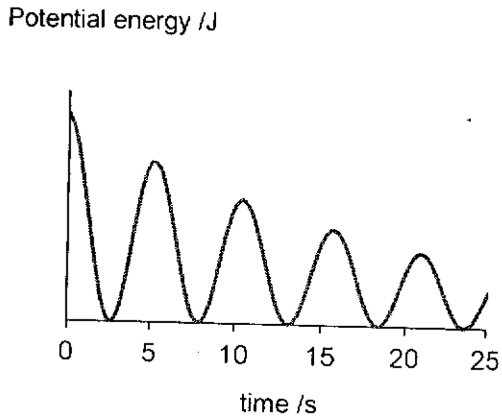
B



C



D



17 A wave of frequency 27 Hz travels at 48 m s^{-1} through a medium.

What is the phase difference between two points 2.0 m apart?

A There is no phase difference.

B They are out of phase by a quarter of a cycle.

C They are out of phase by one-eighth of a cycle.

D They are out of phase by 0.78 of a cycle.

18 Two waves X and Y have the same frequency. The amplitude of X is $1.5A_0$ and the amplitude of Y is $2.0A_0$. The waves meet at a point and superpose to form a resultant wave.

For the resultant wave, what is the ratio $\dfrac{\text{maximum possible intensity}}{\text{minimum possible intensity}}$?

A 2.6 **B** 7 **C** 16 **D** 49

19 A beam of monochromatic light of wavelength 500 nm is incident normally on a diffraction grating. The diffraction grating is placed 1.2 m away from the screen and the horizontal distance between the two second-order maxima is 1.5 m.

What is the number of lines per millimeter of the grating?

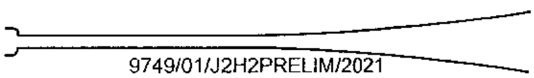
A 530 lines per mm

B 625 lines per mm

C 1250 lines per mm

D 1740 lines per mm

20 A musical instrument is made using a long tube with a mouthpiece at one end. The other end is open and flared, as shown.



A musician maintains stationary sound waves with a node at the mouthpiece and an antinode at the other end. The lowest frequency of sound that the instrument can produce is 80 Hz.

Which different frequencies of sound can be produced by the instrument?

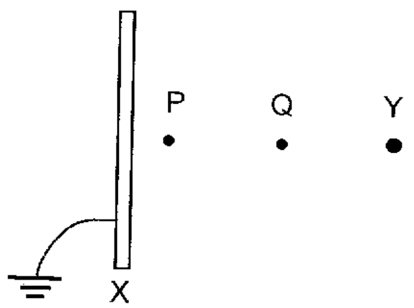
A 80 Hz, 160 Hz, 240 Hz

B 80 Hz, 160 Hz, 320 Hz

C 80 Hz, 240 Hz, 400 Hz

D 80 Hz, 240 Hz, 480 Hz

21 The diagram shows a point charge situated at Y in front of an earthed metal sheet X. Two points P and Q are situated between X and Y and have electric field strengths E_P and E_Q respectively.



Which of the following expressions is correct?

A $E_P = 0$

B $E_Q = 0$

C $E_Q > E_P$

D $E_P > E_Q$

22 A charged oil droplet of mass m is falling, initially freely, in a vacuum between two horizontal metal plates that are separated by a distance x.

A potential difference (p.d.) V is then applied across the plates. This results in the oil droplet continuing to accelerate downwards but with a reduced acceleration a.

The polarity of the applied p.d. is then reversed so that the direction of the electric force on the droplet is reversed. This results in the downwards acceleration of the oil droplet increasing to $5a$.

What is the magnitude of the charge on the oil droplet?

A $\dfrac{max}{V}$ **B** $2\dfrac{max}{V}$ **C** $3\dfrac{max}{V}$ **D** $4\dfrac{max}{V}$

23 A uniform copper rod of cross-sectional area 8.0 mm^2 has 8.2×10^{28} conduction electrons per cubic metre. A current flows through the rod when a potential difference of 3.0 V is applied across it.

Given that the drift velocity of electrons in the rod is 2.3×10^{-5} m s^{-1}, determine the resistance of the rod?

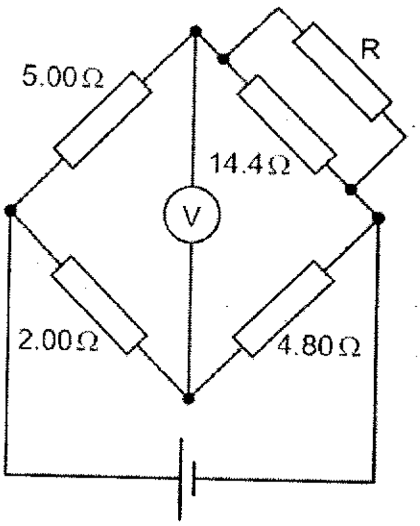
A 0.08 Ω

B 0.16 Ω

C 0.80 Ω

D 1.2 Ω

24 A cell of negligible internal resistance is connected to a network of resistors and a voltmeter, as shown.

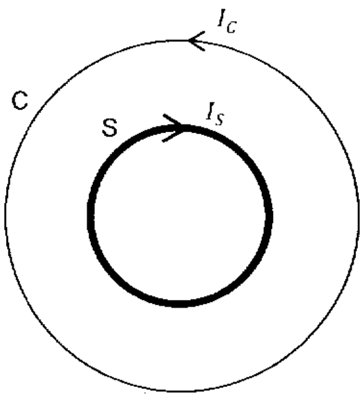


The reading on the voltmeter is zero.

What is the resistance of resistor R?

A 0 Ω **B** 2.40 Ω **C** 14.4 Ω **D** 72.0 Ω

25 A long solenoid S has 15 turns per unit length. A circular loop of wire C is placed over S as shown in the diagram below. S and C are coaxial. A current I_S of 0.20 A is passed through S and a current I_C of 0.90 A is passed through C in the directions shown.

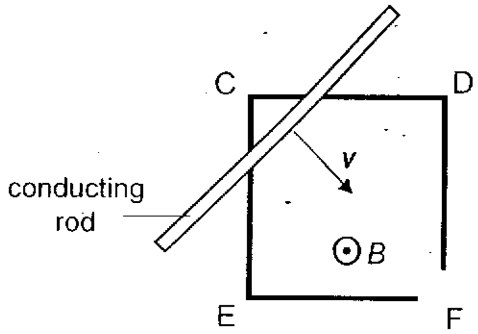


The radius of S is 0.80 m and the radius of C is 1.6 m.

What is the magnitude of the resultant magnetic flux density at the centre of C?

A 0 T **B** 1.0×10^{-6} T **C** 3.4×10^{-6} T **D** 4.1×10^{-6} T

26 A conducting rod slides at constant velocity v across an incomplete conducting square CDEF. The area bounded by the square is in a uniform magnetic field B that points directly out of the page.



How does the induced e.m.f. change as the rod slides from point C to F?

A constant

B increasing

C first increasing, then decreasing

D first decreasing, then increasing

27 An alternating sinusoidal supply is connected to a resistor.

How does the power that dissipates in the resistor change when the frequency of the alternating supply doubles?

A Power drops to half the initial value.

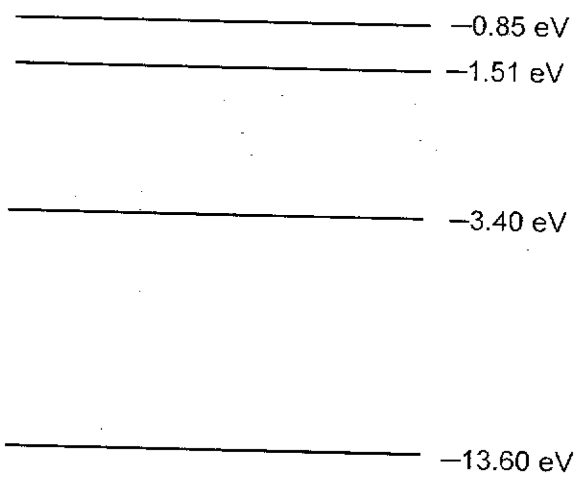
B Power stays the same.

C Power doubles.

D Power quadruples.

28 The diagram below shows some of the lowest energy levels for the hydrogen atom.

The atom is at is ground state.



Which of the following will result in excitation to the highest possible energy level?

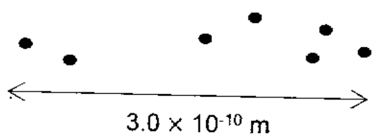
A A photon of energy 10.20 eV incident on the atom.

B An electron of energy 11.50 eV colliding with the atom.

C An electron with de Broglie wavelength of 3.50×10^{-10} m colliding with the atom.

D A photon of wavelength 9.95×10^{-8} m incident on the atom.

29 The dots in the diagram below shows location of an electron detected at several intervals of time.



What is the order of magnitude of the minimum uncertainty in the determination of its momentum?

A 10^{-12} kg m s^{-1}

B 10^{-24} kg m s^{-1}

C 10^{6} kg m s^{-1}

D 10^{10} kg m s^{-1}

30 Electrons gain kinetic energy by accelerating through a large potential difference before striking the target metal to produce X-ray.

What is the percentage change to the minimum wavelength of the X-ray spectrum produced if the potential difference is reduced by half?

A decrease by 25 %

B decrease by 50 %

C increase by 50 %

D increase by 100 %

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PHYSICS

MARK SCHEME

9749/01

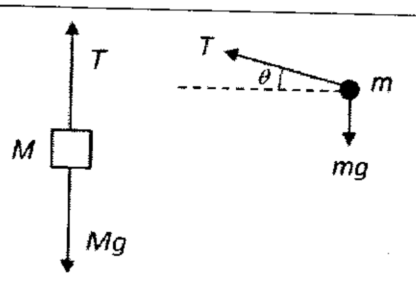
September 2021

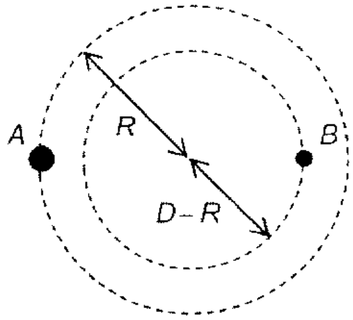
Paper 1
Multiple Choice

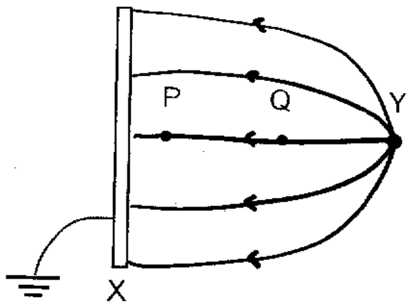
Question	Key	Question	Key	Question	Key
1	D	6	B	11	D
2	C	7	B	12	C
3	A	8	D	13	A
4	C	9	B	14	B
5	B	10	C	15	D
16	C	21	C	26	C
17	C	22	B	27	B
18	D	23	D	28	C
19	A	24	D	29	B
20	C	25	C	30	D

Qn no.	Solution
1	2 Terabyte = 2×10^{12} bytes = $2 \times 10^{12} \times$ (8 bits) = 16×10^{12} bits
2	units of v = units of $T^p\mu^q$ $m\ s^{-1} = (kg\ m\ s^{-2})^p (kg\ m^{-1})^q$ $m\ s^{-1} = kg^{p+q}\ m^{p-q}\ s^{-2p}$ $-1 = -2p \rightarrow p = \frac{1}{2}$ $1 = p - q \rightarrow q = -\frac{1}{2}$
3	$s = ut + \frac{1}{2}at^2$ Considering first 2 points: $9.0 = u(3.0) + \frac{1}{2}a(3.0)^2 ---(1)$ Considering first and third points: $21.0 = u(6.0) + \frac{1}{2}a(6.0)^2 ---(2)$ $(2) - 2\times(1): 3.0 = \frac{1}{2}a\left[(6.0)^2 - 2(3.0)^2\right]$
4	Let H be to initial height and h be the height at time t.

	$v^2 = u^2 + 2as$ $v^2 = 2g(H-h)$ $v^2 + 2gh = 2gH$ $h = -\frac{1}{2g}v^2 + 2gH$ $y = -k_1x^2 + k_2$ Hence it is a negative quadratic graph with vertical intercept k_2
5	When 3 non-parallel forces act on body, all 3 must intersect at a point to achieve rotational equilibrium. For option C, there is a resultant force with a rightward component and a downward component. For D, there is an anticlockwise moment due to the rightmost force about the centre of the block.
6	$P = h\rho g$ $P_R = x\rho_R g = 4 ---(1)$ $P_Q = h2\rho_R g = 9 ---(2)$ $\frac{(2)}{(1)} = \frac{2h}{x} = \frac{9}{4}$ $h = \frac{9}{8}x$
7	$W_{balance} - T = m_{balance}a$ $(800)(9.81) - T = (800)a ---(1)$ $T - W_{car+man} = m_{car+man}a$ $T - (600)(9.81) = 600a ---(2)$ (1) + (2): $(200)(9.81) = 1400a$ $a = 1.4 \text{ m s}^{-2}$
8	$F = N\rho Av^2 = (27)(900)(0.4\times10^{-6})(3.0)^2 = 0.087 \text{ N}$
9	$p_i = p_f$ $(1.0\times10^{27})(1.0\times10^{4}) - (1.0\times10^{30})u_s = (1.0\times10^{27})(-1.0\times10^{4}) + (-1.0\times10^{30})v_s$ $v_s - u_s = 20$

10	$\frac{\text{change in KE}}{\text{time}} = \frac{\text{net work done}}{\text{time}}$ $= \frac{\text{(net force)(displacement)}}{\text{time}}$ $= \text{(net force)}\frac{\text{displacement}}{\text{time}}$ $= \text{(net force)(velocity)}$ $= (500 - 200) \times 10^3 (50)$ $= 15 \text{ MW}$
11	intitial momentum = final momentum mu = (M+m)v gain in GPE = loss in KE $(M+m)gh = \frac{1}{2}(M+m)v^2$ $h = \frac{v^2}{2g} = \frac{1}{2g}\left(\frac{mu}{M+m}\right)^2$
12	efficiency = $\frac{\text{useful output}}{\text{input}} \times 100\%$ $= \frac{\text{electrical power}}{\frac{mgh}{t}} \times 100\%$ $= \frac{100 \text{ MW}}{\frac{m}{t}gh} \times 100\%$ $= \frac{100 \text{ MW}}{1.5 \times 10^5 (9.81)(140)} \times 100\%$ $= 49\%$
13	 The horizontal component of tension T provides the centripetal force. $T = Mg$ ......(1) $T\sin\theta = mg$ ......(2) $T\cos\theta = m\frac{v^2}{r}$ ......(3) Solving using $\sin^2\theta + \cos^2\theta = 1$, $M = m\sqrt{1 + \left(\frac{v^2}{rg}\right)^2}$

14	Gravitational force on A and on B = $\frac{GM_A M_B}{D^2}$ For A: $\frac{GM_A M_B}{D^2} = M_A R\omega^2$ For B: $\frac{GM_A M_B}{D^2} = M_B(D-R)\omega^2$ 
15	Using Formula PV = nRT, It is observed that T_M is lowest, T_N is the highest. Using the same formula, T and V relationship between M and N is linear since P is constant.
16	There are 2 cycles of the potential energy variation in one period. In the case of significant damping, the natural frequency of the system (or the frequency at which resonance occurs) would decrease. This means that the period of oscillation of the system will increase.
17	In terms of number of cycles, phase difference = $\frac{\Delta x}{\lambda} = \frac{2.0}{v/f} = \frac{2.0}{48/27} = 1.125$ Difference of 1.125 is the same as 0.125 of a cycle since the cycle repeats itself.
18	$\frac{\text{maximum possible intensity}}{\text{minimum possible intensity}} = \left(\frac{\text{maximum possible amplitude}}{\text{minimum possible amplitude}}\right)^2$ $= \left(\frac{2.0A_0 + 1.5A_0}{2.0A_0 - 1.5A_0}\right)^2$ $= 49$

19	$\tan\theta = 0.75 / 1.2$ $\theta = 32.005°$ $d \sin\theta = n\lambda$ $d = (2)(500 \times 10^{-9}) / \sin(32.005°)$ $= 1.887 \times 10^{-3}$ mm $d^{-1} = 529.9$ $= 530$ lines per mm
20	Fundamental: N A → $\lambda = 4L$ → $f = 80$ Hz 1st overtone: N A N A → $\lambda = 4/3\ L$ → $f = 3 \times 80$ Hz $= 240$ Hz 2nd overtone: N A N A N A → $\lambda = 4/5\ L$ → $f = 5 \times 80$ Hz $= 400$ Hz 
21	 Field lines are closer at Q compared to P, hence larger field strength at Q.
22	case 1: $W - F_E = ma$ $W - q\frac{V}{x} = ma$ case 2: $W + F_E = ma$ $W + q\frac{V}{x} = m(5a)$ $(2)-(1): 2q\frac{V}{x} = 4ma$ $q = 2\frac{max}{V}$
23	$I = nqvA$ $= (8.2 \times 10^{28})(1.6 \times 10^{-19})(2.3 \times 10^{-5})(8.0 \times 10^{-6})$ $= 2.41$ A Resistance of the rod $= V/I = 3.0/2.41 = 1.2\ \Omega$

24	Since there is no p.d. across the voltmeter, the p.d.s across 14.4Ω and 4.80Ω resistors are the same. $$\frac{5.00}{R'} = \frac{2.00}{4.80}$$ $$R' = 12.0\Omega$$ Hence $$\left(\frac{1}{R} + \frac{1}{14.4}\right)^{-1} = 12.0\Omega$$ $$R = 72.0\Omega$$
25	$B_S = \mu_0 nI = 4\pi \times 10^{-7} \times 15 \times 0.20$ $B_C = \frac{\mu_0 NI}{2r} = \frac{4\pi \times 10^{-7} \times 0.90}{2 \times 1.6}$ $B_{resultant} = B_S - B_C = 3.4 \times 10^{-6}$ T
26	E.m.f. is induced in the part of the length of the rod that forms a closed loop with the square. This length first increases than decreases, thus the e.m.f. induced will first increase, then decrease. OR: Part of the rod forms a closed loop with the square. Magnetic flux linkage with this loop changes as the rod moves. The e.m.f. induced in the loop is proportional to the rate of increase of the area of the loop. This rate of increase of loop area first increases then decreases. Thus induced e.m.f. increases, then decreases.
27	Power is independent of frequency. The area under the power-time remains the same regardless of frequency.
28	$E = \frac{p^2}{2m} = \frac{\left(\frac{h}{\lambda}\right)^2}{2m} = 12.31$ eV The electron can lose part of its kinetic energy and will result in excitation to −1.51 eV. Note: Option D is not the answer because the photon will not be absorbed as its energy is not exactly equal to the difference between the energy levels.
29	$\Delta x \Delta p \geq h$ Since $\Delta x = 3.0 \times 10^{-10}$ m $\Delta p \geq \frac{h}{3.0 \times 10^{-10}} = \frac{6.63 \times 10^{-34}}{3.0 \times 10^{-10}}$ $\Delta p \geq 2.21 \times 10^{-24}\ kg\ m\ s^{-2}$
30	KE = qV = hc/λ_{min} If V is reduced by ½ , λ_{min} is increased to 2 times (100 %)