EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2022
General Certificate of Education Advanced Level
Higher 2

PHYSICS 9749

MARK SCHEME

Aug/Sep 2022

Paper 1
Multiple Choice

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

1 mass of electron negligible compared to nucleons

question similar to asking for nuclear density:

$$\rho_{\text{material}} \approx \frac{\text{mass}}{V_{\text{nucleus}}} = \frac{\cancel{A}u}{\frac{\cancel{4}}{\cancel{3}}\cancel{\pi} r_{\text{nucleus}}^3}$$

$$\approx \frac{10^{-27}}{10^{-45}} = 10^{18}\ \text{kg m}^{-3}$$

2 $R = s\left(\frac{Et^2}{\rho}\right)^{0.2}$

$$\text{units of } s = \text{units of } R\left(\frac{Et^2}{\rho}\right)^{-0.2}$$

$$= \text{m}\left(\frac{(\cancel{\text{kg}}\ \text{m}^2\ \cancel{\text{s}^{-2}})(\cancel{\text{s}^2})}{\cancel{\text{kg}}\ \text{m}^{-3}}\right)^{-0.2}$$

$$= \text{m}(\text{m}^5)^{-0.2} = 1\ (\text{dimensionless})$$

3 constant acceleration so

$$s = ut + \frac{1}{2}at^2 = t\left(u + \frac{-g}{2}t\right)$$

$$0 = u + \frac{-9.81}{2}(3.20)$$

$$u = 15.7\ \text{m s}^{-1}$$

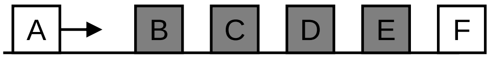
4 upthrust depends on weight of fluid displaced so need to displace a greater volume of fluid, increase either x or z

5 each spring supports 4 N; area under force-extension graph up till 4 N:
$\frac{1}{2}(3\times10^{-2})(4) = 0.060$ J

6 a counter example is friction between tyres exists, but does not reduce total energy when there is no slippage even as vehicle (the machine) does work (increase KE)

7 apply knowledge from Newton's cradle that transfer of KE between 2 masses is 100% if masses are equal and one mass is initially stationary

we model the system as separated blocks doing elastic collisions, take right +ve:



consider A and B only:

$$\text{PCLM: } m_A u_A + 0 = m_A v_A + m_B v_B$$

$$\text{relative speed: } v_B - v_A = 10$$

$$\cancel{m}(10) = \cancel{m}v_A + (4\cancel{m})(v_A + 10)$$

$$10 = 5v_A + 40$$

$$v_A = -\frac{30}{5} = -6 \text{ m s}^{-1}$$

$$v_B = v_A + 10 = 4 \text{ m s}^{-1}$$

so A will move left. B will undergo newton's cradle style collision until E moves to hit F

consider E and F only

$$\text{PCLM: } m_E u_E + 0 = m_E v_E + m_F v_F$$

$$\text{relative speed: } v_F - v_E = 4$$

$$(4\cancel{m})(4) = (4\cancel{m})v_E + \cancel{m}(4 + v_E)$$

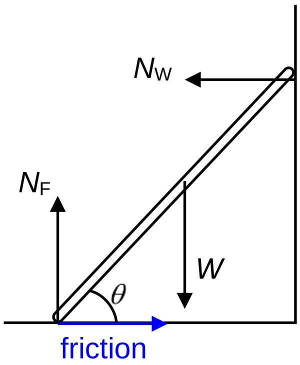
$$16 = 5v_E + 4$$

$$v_E = \frac{12}{5} = +2.4 \text{ m s}^{-1}$$

$$v_F = \frac{32}{5} = +6.4 \text{ m s}^{-1}$$

so both E and F moves to the right. that leaves B, C and D at rest.

8 sketch in order visualize



$$N_F = W$$

$$N_W = \text{friction}$$

pivot at wall

$$W\left(\frac{\cancel{L}}{2}\cos\theta\right) + (\text{friction})(\cancel{L}\sin\theta)$$

$$= N_F(\cancel{L}\cos\theta)$$

$$N_F = \frac{W}{2} + N_W \tan\theta$$

$$N_W \tan\theta = N_F - \frac{W}{2}$$

9 tension in string 1 provides centripetal force for 3 masses so must be largest magnitude; eliminate **A** and **C**

centre of mass of 3 separate masses is at centre i.e. mass 2 so tension in string 1 is equivalent to a string providing centripetal force to a mass of 3m at radius 2r:

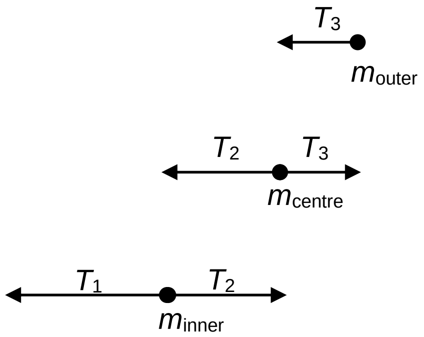
$$T_1 = (3m)(2r)\omega^2$$
$$T_3 = m(3r)\omega^2$$

$$\frac{T_1}{T_3} = 2$$

eliminate **B**

or

via considering free bodies:



T_3 provides centripetal force on outer mass
$$m(3r)\omega^2 = T_3$$

vector sum of T_2 and T_3 provides centripetal force on centre mass
$$m(2r)\omega^2 = T_2 - T_3$$
$$T_2 = m(2r)\omega^2 + T_3$$
$$= m(2r)\omega^2 + m(3r)\omega^2$$
$$= m(5r)\omega^2$$

vector sum of T_2 and T_1 provides centripetal force on inner mass
$$mr\omega^2 = T_1 - T_2$$
$$T_1 = mr\omega^2 + T_2$$
$$= mr\omega^2 + m(5r)\omega^2$$
$$= m(6r)\omega^2$$

10 mass on moon needs just enough KE to reach location of 0 field strength, then it will accelerate towards earth "from rest":

$$\text{loss in KE} = \text{gain in EPE}$$
$$\frac{1}{2}\cancel{m}v^2 - 0 = \cancel{m}(\Delta\phi)$$
$$v^2 = 2(\text{smaller area})$$
$$v = \sqrt{2(2.6\times10^6)}$$
$$= 2280 \text{ m s}^{-1}$$

11 satellite is now further away from earth so GPE must increase

12 kinetic energy is directly proportional to thermodynamic temperature

$$\frac{3}{\cancel{2}}kT = \frac{1}{\cancel{2}}mv^2$$
$$v = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3k}{m}}\left(\sqrt{T}\right)$$

$$\frac{v_{\text{new}} - v_{\text{old}}}{v_{\text{old}}} \times 100\%$$
$$= \frac{\sqrt{T_{\text{new}}} - \sqrt{T_{\text{old}}}}{\sqrt{T_{\text{old}}}} \times 100\%$$
$$= \frac{\sqrt{273.15+40.5} - \sqrt{273.15+32.1}}{\sqrt{273.15+32.1}}$$
$$= 1.4\%$$

13 $pv = NkT \rightarrow p = \dfrac{Nk}{V}(T)$

X has less steep gradient

14 coin loses contact when piston retracts downwards at an acceleration larger than magnitude of free fall acceleration i.e.

$$|a_{\text{SHM}}| \geq |g|$$
$$(\omega^2)x_0 \geq g$$
$$= (2\pi f)^2 x_0$$
$$f = \sqrt{\frac{9.81}{0.07}\frac{1}{4\pi^2}}$$
$$= 1.9 \text{ Hz}$$

15 $\lambda = 2(0.90) = 1.80$ m

$$\frac{\Delta\phi}{2\pi} = \frac{\Delta x}{\lambda}$$

$$\Delta\phi = (360^\circ)\left(\frac{\Delta x}{\lambda}\right)$$

$$= (360^\circ)\left(\frac{1.30}{1.80}\right)360$$

$$= 260^\circ$$

16 check for max observable order for violet:

$$d \sin\theta = n\lambda$$

let $\sin\theta \to 1$

$$n \to \frac{d}{\lambda} = \frac{\frac{1\times10^{-2}}{5000}}{400\times10^{-9}}$$

$$= 5$$

fourth order violet is visible

17 aim is the NOT distinguish the pixels

hence use the smallest wavelength to determine the shortest pixel distance that can be distinguished.

$$\sin\,\theta \approx \frac{\lambda}{b} \approx \frac{s}{r}$$

for maximum distance between pixels s_{max}, we consider shortest wavelength (blue):

$$\frac{d}{0.1} < \frac{\lambda}{b}$$

$$\frac{d}{0.1} < \frac{470\times10^{-9}}{4.0\times10^{-3}}$$

$$d < 1.2\times10^{-5} \text{ m}$$

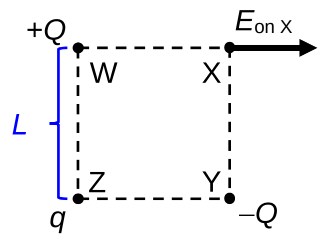
18 connecting wire so all metallic surfaces at same potential

$$V_1 = V_2$$

$$\cancel{\left(\frac{1}{4\pi\varepsilon_0}\right)}\frac{q_1}{r_1} = \cancel{\left(\frac{1}{4\pi\varepsilon_0}\right)}\frac{q_2}{r_2}$$

$$\frac{E_1}{E_2} = \frac{\cancel{\left(\frac{1}{4\pi\varepsilon_0}\right)}\left(\frac{q_1}{r_1^2}\right)}{\cancel{\left(\frac{1}{4\pi\varepsilon_0}\right)}\left(\frac{q_2}{r_2^2}\right)} = \frac{\left(\frac{q_1}{r_1}\right)\frac{1}{r_1}}{\left(\frac{q_2}{r_2}\right)\frac{1}{r_2}} = \frac{r_2}{r_1}$$

19 electric force is vector quantity, and the charge at X is negative so electric field strength actually points to right:



$$\overrightarrow{E_X} = \overrightarrow{E_{\text{by W}}} + \overrightarrow{E_{\text{by Z}}} + \overrightarrow{E_{\text{by Y}}}$$

vertically :

$$0 = \frac{q}{L^2+L^2}\cos\,45^\circ - \frac{Q}{L^2}$$

$$= \frac{q}{L^2+L^2}\cos\,45^\circ - \frac{Q}{L^2}$$

$$= \frac{q}{2L^2}\frac{1}{\sqrt{2}} - \frac{Q}{L^2}$$

$$q = \frac{2\sqrt{2}\cancel{L^2}}{\cancel{L^2}}Q$$

20 resistance of R_3 alone is larger than the effective resistance of R_2 in parallel with R_3

by potential divider rule:

p.d. across R_1 larger

p.d. across R_3 smaller

total circuit resistance drops so battery outputs more power $P = \dfrac{(\text{emf})^2}{R_{\text{total}}}$

21 by potential divider rule:

$$\frac{R_1}{R_1+R_2}E_{\text{sec}}=\frac{60}{L}E_{\text{main}} \qquad \_\_\_\_(1)$$

$$\frac{R_2}{R_1+R_2}E_{\text{sec}}=\frac{20}{L}E_{\text{main}} \qquad \_\_\_\_(2)$$

$$\frac{(2)}{(1)}:\frac{R_2}{R_2}=\frac{20}{60}=\frac{1}{3}$$

22 with resistor across A and B, there is complete circuit for which induced current can flow, so there is damping on oscillations.

23 consider change in magnetic flux:

$$\begin{aligned}\Delta(BA)&=A(B_{\text{final}}-B_{\text{initial}})\\&=-2AB_{\text{initial}}\\&=-2(25\times10^{-4})(2.0\times10^{-4})\sin 60^\circ\\&=-\left(\frac{\sqrt{3}}{2}\right)(10^{6})\end{aligned}$$

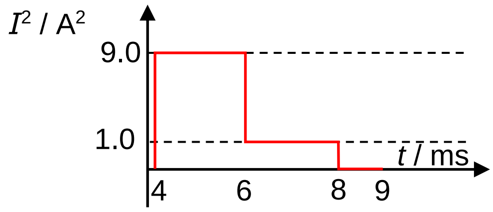
by Faraday's law, induced e.m.f. E is:

$$\begin{aligned}|E|&=\frac{\text{d}}{\text{d}t}(N\phi)\\&=IR=\left(\frac{\text{d}}{\text{d}t}Q\right)R\end{aligned}$$

$$\Delta N\phi=R\langle Q\rangle$$

$$\begin{aligned}\langle Q\rangle&=\frac{N\Delta\phi}{R}=\frac{N\Delta BA}{R}\\&=\frac{(500)\frac{\sqrt{3}}{2}(10^{-6})}{5.0}\\&=8.66\times10^{-5}\text{ C}\end{aligned}$$

24 1 period is 5 ms



$$\begin{aligned}\text{area under } I^2 \text{ graph}&=(9)(2)+(1)(2)\\&=20\text{ A}^2\text{ ms}^2\end{aligned}$$

$$\begin{aligned}\text{mean square } I&=\frac{20}{T}=\frac{20}{5}\\&=4\text{ A}^2\\I_{\text{rms}}&=2\text{ A}\\\langle P\rangle&=I_{\text{rms}}^2R=52\text{ W}\end{aligned}$$

25 low intensity high freq can result in photoelectric effect, eliminate **A**

$$\left.\begin{aligned}hf-\Phi&=eV_s\\h(2f)-\Phi&\neq e(2V_s)\end{aligned}\right\}\text{eliminate } \mathbf{B}$$

statement is correct for **min frequency** so should have been *max* wavelength, eliminate **C**

intensity can mean increased energy per photon or more photons

26 electron KE converted to photon:

$$eV=\frac{hc}{\lambda}$$

$$V=(\lambda^{-1})$$

$$\lg V=\lg\frac{hc}{e}+(-1)\lg\lambda$$

straight line with negative gradient

27 by Heisenberg's uncertainty principle,

$$\Delta p \Delta x \geq h$$

$$\Delta p = \left(\frac{0.20}{100}\right) m_e v$$

$$\Delta x = \frac{h}{\Delta p} = \frac{h}{\left(\frac{0.20}{100}\right) m_e v}$$

$$= \frac{6.63 \times 10^{-34}}{\left(\frac{0.20}{100}\right)\left(9.11 \times 10^{-31}\right)\left(1.5 \times 10^{6}\right)}$$

$$= 2.4 \times 10^{-7} \text{ m}$$

28 $C = (C_0)\exp(-\lambda t) + C_{\text{bg}}$

$$= (77.3 - 8.3)\exp\left(-\frac{\ln 2}{752}(280)\right) + 8.3$$

$$= 61.6 \text{ s}^{-1}$$

29 energy needed in reaction

$$= (m_{\text{H}} + m_{\text{O}} - m_{\text{N}} - m_{\alpha})uc^2$$

$$= \begin{pmatrix} 1.007825 + 16.999130 \\ -14.003074 - 4.002604 \end{pmatrix} uc^2$$

$$= 0.001277\left(1.66 \times 10^{-27}\right)\left(3 \times 10^{8}\right)^2$$

$$= 1.91 \times 10^{-13} \text{ J} = 1.19 \times 10^{6} \text{ eV}$$

30 Isotope P could be formed from isotope Y after 2 successive alpha decays.

Isotope R could be formed from isotope Y after an alpha decay followed by a beta decay (or a beta decay followed by an alpha decay).