2021 Raffles Institution Preliminary Examinations H2 Physics Paper 1 Solutions

1 **B**

$$\rho = \frac{m}{V} = \frac{m}{\frac{4}{3}\pi r^3} = \frac{80}{\frac{4}{3}\pi(2.0)^3} = 2.3873 \text{ g cm}^{-3}$$

$$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 3\frac{\Delta d}{d} \quad \left(\text{or } \frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 3\frac{\Delta r}{r}\right)$$

$$\frac{\Delta\rho}{\rho} = \frac{2}{80} + 3\frac{0.1}{4.0}$$

$$\Delta\rho = 0.24 = 0.2 \text{ (1 s.f.)}$$

$$\rho = (2.4 \pm 0.2) \text{ g cm}^{-3}$$

2 **C** Between t_1 and t_2, displacement increases at increasing rate. Between t_2 and t_3, displacement increases at decreasing rate. After t_3, the displacement remains constant as velocity is zero.

3 **B** Gradient of the first graph gives resultant force in the *y*-direction, which is a constant. Hence, acceleration in the y-direction is constant.
Gradient of the second graph gives velocity in the *x*-direction, which is a constant.
This is similar to a scenario of an object moving in a projectile (parabolic path) under constant acceleration of free fall.

4 **C** Gradient = $\frac{14}{4} \quad \Rightarrow \quad \frac{8}{t_1} = \frac{14}{4}$

t_1 = 2.29 s

change in momentum = area under graph
= ½ (2.29)(8) – ½ (4 – 2.29)(6)
= 4.03 N s

5 **B** For equilibrium, the lines of action of three non-parallel forces must intersect at a single point. The three forces should form a closed triangle.

6 **C**

$$U_{balloon} + U_{block} = kx + W$$

$$(0.015)(1000)g + (0.005)(1000)g = 5000x + 60$$

$$x = 0.0272 \text{ m}$$

7 **D**

$$F - mg = ma$$

$$F - 0.80 \times 9.81 = 0.80 \times 1.0$$

$$F = 8.648 \text{ N}$$

$$W = F \times d = 8.648 \times 2.0 = 17.296 \text{ J}$$

$$\text{Energy Input } = \frac{10}{6} \times 17.296 = 28.8\ J$$

8 **D**

$$\frac{1}{2}kx^2 = mgh$$

$$x = \sqrt{\frac{2mgh}{k}} = \sqrt{\frac{2 \times 0.22 \times 9.81 \times 0.40}{350}} = 7.02 \times 10^{-2} \text{ m}$$

9 **A** $a = r\omega^2 = (75)\left(\dfrac{2\pi}{30\times 60}\right)^2 = 9.14\times 10^{-4}\ \text{m s}^{-2}$

10 **D** $F = mr\omega^2 = \dfrac{mv^2}{r} = mv\omega$

$F' = m\left(\dfrac{v}{2}\right)(2\omega) = F$

11 **B** Gain in KE $=$ Loss in PE $= mgh = m\left(\dfrac{GM}{R^2}\right)h = \dfrac{GMmh}{R^2}$

12 **A** $g = \dfrac{GM}{R^2} = \dfrac{G}{R^2}\left(\dfrac{4}{3}\pi R^3\rho\right) = \dfrac{4\pi G}{3}\rho R$

Hence, $\dfrac{g_M}{g_E} = \dfrac{\rho_M R_M}{\rho_E R_E} = 0.50\times 0.70 = 0.35$

Therefore, $\dfrac{W_M}{W} = \dfrac{mg_M}{mg_E} = 0.35$

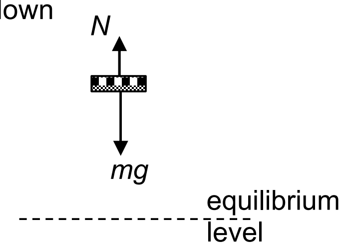
13 **A** When the platform is above the equilibrium level, and moving down

$mg - N = m\omega^2 x$

When the coin loses contact with the platform, $N = 0$

$\therefore mg = m\omega^2 x_0 \quad \Rightarrow \quad \omega^2 x_0 = g$

$\Rightarrow x_0 = \dfrac{g}{\omega^2} = \dfrac{9.81}{(2\pi\times 3.2)^2} = 0.0243\ \text{m}$



14 **A** This is derived from $pV = \dfrac{1}{3}Nm\langle c^2\rangle$ and is not an assumption.

15 **B** Work done on gas = $25\times 10^3\times(80-40)\times 10^{-3} = 1000$ J
$\Delta U = Q + W = -2500 + 1000 = -1500$ J
Avoid using $\Delta U = \dfrac{3}{2}\Delta(PV)$ as the gas may not be monatomic.

16 **A** $\dfrac{I}{I_0} = \cos^2\theta \quad \Rightarrow \quad 0.25 = \cos^2\theta \quad \Rightarrow \quad \theta = 60^0$

new $\dfrac{I}{I_0} = \cos^2 90 = 0$

17 **B** $I = \dfrac{P}{4\pi r^2}, \qquad I = kA^2$

$kA^2 = \dfrac{P}{4\pi r^2} \quad \Rightarrow \quad A = \sqrt{\dfrac{P}{4\pi k}}\times\dfrac{1}{r}$

Amplitude is inversely proportional to distance (first graph).
Intensity is proportional to amplitude^2 (second graph).

18 **C** $x = \dfrac{7.5\times10^{-3}}{9.5}$

$\dfrac{\lambda}{d} = \dfrac{x}{D} \quad \Rightarrow \quad \lambda = d\left(\dfrac{x}{D}\right) = 0.45\times10^{-3}\left(\dfrac{7.5\times10^{-3}}{0.70\times9.5}\right) = 5.08\times10^{-7}\ \text{m}$

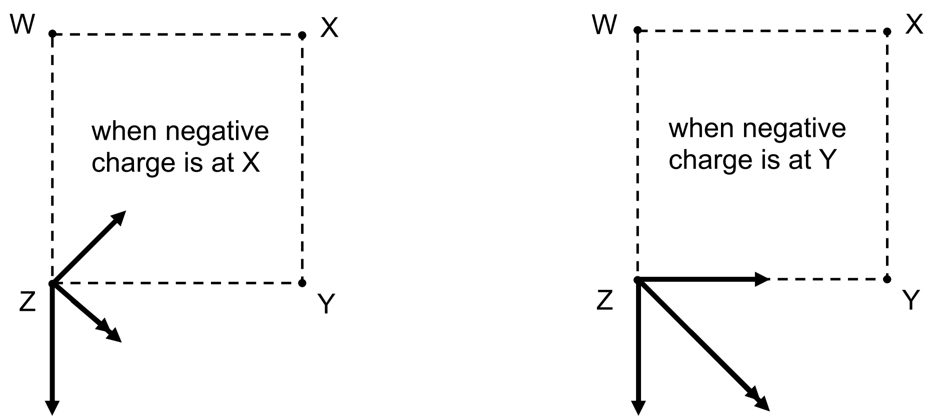
19 **D** $d\sin\theta = n\lambda$, where $\sin\theta = 1$ at max. order

$n_{\text{max}} = \dfrac{d}{\lambda} = \dfrac{\left(\dfrac{10^{-3}}{500}\right)}{633\times10^{-7}} = 3.16 \quad \rightarrow \quad n = 3$

number of maximas = 7 (3 maximas on both sides of the central maxima)

20 **C** Electric field lines point from higher potential to lower potential and must be perpendicular to equipotential lines.

21 **B**



When negative charge is moved to Y, distance to Z is shorter. In addition, the vector sum of the two perpendicular electric field strengths will result in a resultant field strength of higher magnitude as shown above.

22 **D** total energy delivered by the battery = 2500 + 500 = 3000 J

e.m.f. $= \dfrac{\text{total energy}}{\text{total charge}} = \dfrac{3000}{1500} = 2.00\ \text{V}$

23 **C** Increasing R_4 increases the effective resistance of the combination of R_2 and R_4 in parallel. By potential divider rule, the p.d. across the parallel combination increases. Since R_2 remains constant, the ammeter reading will increase.

24 **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.

25 **C** For coil to remain horizontal,

$$\text{torque due to magnetic force} = mg\left(\frac{6.8-2.5}{100}\right)$$

$$BIL\left(\frac{15}{100}\right) = mg\left(\frac{6.8-2.5}{100}\right)$$

$$\left(60\times10^{-3}\right)(I)\left(\frac{3.0}{100}\right)\left(\frac{15}{100}\right) = \left(\frac{5.0}{1000}\right)(9.81)\left(\frac{4.3}{100}\right)$$

$$I = 7.81\text{ A}$$

26 **D** The coil is connected to an ammeter (a closed circuit), so there is induced current in the circuit. By Lenz's law, the magnetic force acting on the induced current should oppose the rotation of the coil. Hence, the rotation will slow down, the period of rotation will increase. So, the answer is either B or D.
According to Faraday's law, the emf induced is proportional to the rate of change of the flux linkage. If the rotation slows down, the rate of change of the flux linkage decreases, hence the amplitude of the graph will decrease. The answer is **D**.
Mathematically,

$$\text{emf} = -\frac{d\Phi}{dt} = -NBA\frac{d}{dt}\cos\omega t = NBA\omega\sin\omega t$$

As the rotation of the coil slows down, the period T increases and $\omega = 2\pi f = \frac{2\pi}{T}$ (hence the amplitude $NBA\omega$) decreases.

Note: The magnetic force damps the rotation of the coil. But take note of the difference between this damping and the other examples of damping of SHM, such as a spring-mass system in water. For a spring-mass system in water, its amplitude and period of oscillation are unrelated. When damped, its amplitude will decrease exponentially in time, but its period (or frequency) can be taken to be unchanged.

27 **A** In the initial orientation, the component of B perpendicular to the area is
$B_\perp = 0.15 \times 10^{-3} \times \sin 10° = 2.60 \times 10^{-5}$ T
initial flux linkage, $\Phi_{\text{ini}} = B_\perp nA = 2.60 \times 10^{-5} \times 5 \times 0.12 = 1.56 \times 10^{-5}$ Wb.
The final flux linkage is 0 when the angle becomes 0.
Hence, the change in flux linkage is 1.56×10^{-5} Wb.

28 **D**

mean power $P = \frac{I_0^{\,2}R}{2}$

new mean power $P' = \frac{(2I_0)^2 R}{2} = \frac{4I_0^{\,2}R}{2} = 4P$

29 **D**

$$p = \sqrt{2mE_k}$$

$$\frac{\Delta p}{p} = \frac{1}{2}\frac{\Delta E_k}{E_k} = \frac{1}{2}(0.0010) = 0.00050$$

$$\Delta p = 0.00050p$$

$$\Delta x \geq \frac{h}{\Delta p} = \frac{h}{0.00050p} = 2000\frac{h}{p}$$

30 **B** If a red filter is used, only red light incidents on the metal. Red light photons have lower energy than yellow. Hence, no photoelectric effect will be observed.