Suggested solutions to 2020 A-Level H2 Physics Paper 1

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

Q	Ans	Working
1	B	$V = \frac{4}{3}\pi r^3$ $\frac{\Delta V}{V} = 3\frac{\Delta r}{r}$ A graph of $\frac{\Delta V}{V}$ against $\frac{\Delta r}{r}$ will produce a straight line graph passing through the origin with a gradient of 3.
2	D	Both weight of car and normal contact force on car are forces acting on the same object – car. For action-reaction force pair, one of the conditions is for the forces to be acting on different bodies.
3	D	Units for stress: $\frac{[F]}{[A]} = \frac{\mathrm{J\,m^{-1}}}{\mathrm{m^2}} = \mathrm{Jm^{-3}}$ There is no units for strain (length / length). Area under stress-strain graph will have a unit equivalent to (units for stress) × (units for strain)
4	A	Area under *v-t* graph is equivalent to displacement. To overtake, both vehicles must have travelled the same displacement to be side-by-side. P+Q+R = Q+R+S
5	C	Relative velocity of bicycle to car = $v_{\text{bicycle}} - v_{\text{car}}$ Vector of velocity of bicycle + negative vector of velocity of car.
6	C	In order for yacht to be in equilibrium, the net torque on the yacht should be zero. Hence the torque due to vertical and horizontal force-pairs should be equal and **opposite** so that their vector sum is zero.
7	B	For torque due to a couple (force pair where both forces are equal, opposite and parallel), $Force \times d_{\perp}$ The perpendicular component of distance to the force is $d\sin\theta$
8	A	There are 5 forces on the hot air balloon: Upwards: Upthrust due to cold air being displaced. Downwards: weight of hot air, weight of basket and balloon, 2×tension due to the rope $W_{\text{hot air}} + W_{\text{basket}} + 2T = U_{\text{cold air}}$ $V\rho_{\text{hot air}}g + m_{\text{basket}}g + 2T = V\rho_{\text{cold air}}g$
9	D	Power (useful) by driving force $= Fv = 1600(22) = 35.2$ kW

		Thermal power from fuel $= \frac{E}{t} = \frac{3.3\times10^6}{60} = 55$ kW Efficiency $= \frac{35.2}{55}\times100\% = 64\%$
10	**B**	$a = r\omega^2 = r\left(\frac{2\pi}{T}\right)^2$ $= \left(3.85\times10^8\right)\left(\frac{2\pi}{27.3(24\times60\times60)}\right)^2 = 2.73\times10^{-3}$ m s^{-2}
11	**B**	$\omega = \left(\frac{2\pi}{T}\right) = \left(\frac{2\pi}{60\times60}\right) = 1.75\times10^{-3}$ rad s^{-2} Note: Minute hand of analogue clock takes 1 hour (3600 s) to complete one revolution
12	**A**	Increase in $E_p = E_{p,final} - E_{p,initial}$ $= \left(-\frac{Gm_1m_2}{2r}\right) - \left(-\frac{Gm_1m_2}{r}\right) = \left(\frac{Gm_1m_2}{2r}\right)$
13	**A**	$g = \frac{GM}{r^2} = \frac{(6.67\times10^{-11})(2\times10^{31})}{(150\times10^9)^2}$
14	**B**	$pV = nRT$ $T = \frac{p}{nR}V$ From L to M, gradient $\frac{p}{nR}$ is constant since pressure is constant. It is a straight line graph for L to M with positive gradient. **Note**: MN is not the correct answer as temperature is decreasing along MN. MN is not isothermal change.
15	**B**	Since volume is constant in experiment 1, the work done by the gas is zero. Hence by first law of thermodynamics, the increase in internal energy is the same as the heat supplied to the gas.
16	**A**	Maximum potential energy = maximum kinetic energy $E = \frac{1}{2}m\omega^2x_0^2$ $\frac{E_{\text{new}}}{E} = \left(\frac{x_{0,\text{new}}}{x_0}\right)^2$ $x_{0,\text{new}} = x_0\sqrt{\frac{E - \frac{E}{4}}{E}} = 0.866x_0$ Since the question asks for the **change in amplitude**, it will be 0.134*x*. **Note**: Need to be careful in reading question. New energy is E/4 not reduced by E/4.
17	**C**	The two graphs are out of phase by a quarter of a cycle. $\frac{1}{4}(2\pi) = \frac{\pi}{2}$
18	**C**	Between two points of compression (at 4 m and 12 m), it is equivalent to a distance of 1 wavelength. $\lambda = 8$ m

		$f = \frac{v}{\lambda} = \frac{12}{8} = 1.5$ Hz
19	**D**	In single slit diffraction equation: $\sin\theta = \frac{\lambda}{b}$ The angle θ is the angle between the central maximum and the first minimum. Hence, the angle θ is equivalent to a distance of x/2 on the screen. By using a right-angled triangle, we can relate x, D and θ: $\sin\theta = \frac{\frac{x}{2}}{D} = \frac{x}{2D}$ Hence, $\frac{\lambda}{b} = \frac{x}{2D}$ and c = fλ $$b = \frac{2Dc}{fx}$$ **Note**: x is the width of the central maximum. To use equation correctly, this a factor of 2 needs to be included.
20	**C**	$$V = \frac{Q}{4\pi\epsilon_0 d}$$ Since V is inversely proportional to d, electric potential V will be doubled when d is halved.
21	**A**	$$E = \frac{Q}{4\pi\epsilon_0}\frac{1}{r^2}$$ For a graph of E against $\frac{1}{r^2}$, gradient $= \frac{Q}{4\pi\varepsilon_0}$
22	**B**	$P = \frac{V^2}{R}$ $\quad R = \frac{\rho\ell}{\pi\left(d/2\right)^2} = \frac{4\rho\ell}{\pi d^2}$ $P = \frac{V^2\pi d^2}{4\rho\ell}$ $\frac{P_X}{P_Y} = \left(\frac{d_X}{d_Y}\right)^2$ $\frac{1.0}{1.5} = \left(\frac{d_X}{d_Y}\right)^2$
23	**A**	$I_{\text{circuit 1}} = \frac{E}{2R + r}$ $I_{\text{circuit 2}} = \frac{E}{0.5R + r}$ $\quad$ [note that 2 R are parallel] $\frac{E}{0.5R + r} = 2 \times \left(\frac{E}{2R + r}\right)$
24	**B**	Use potential divider rule. When X slides to the top end nearest to Y, the resistance across XY is 0 and p.d. = 0. When X slides to the bottom end furthest to Y, the resistance across XY is R and p.d. = $\frac{R}{2R} \times 6.0 = 3.0$ V
25	**B**	Using horizontal component to find the time taken for the first 5.00 cm:

		$t=\dfrac{s_x}{u_x}=\dfrac{5\times10^{-2}}{1.97\times10^{7}}$ Then vertical components to find the change in height: $\Delta h=ut+\dfrac{1}{2}at^2\ =0+\dfrac{1}{2}\left(\dfrac{F}{m}\right)t^2$ $=\dfrac{1}{2}\left(\dfrac{Vq}{dm}\right)\left(\dfrac{5\times10^{-2}}{1.97\times10^{7}}\right)$
26	**D**	Flux linkages$=$ NBA $=10\left(2.1\times10^{-5}\right)\left(20\times20\right)$
27	**C**	$P_{avg}\ =\ I^2_{\mathrm{r.m.s.}}R$
28	**D**	E_1 is higher energy level since a photon released required de-excitation from higher to lower energy level. $E_1-E_2=\dfrac{hc}{\lambda}$
29	**A**	Use mass defect and $E=\Delta m\cdot c^2$ $E=\left(m_{^{235}_{92}\mathrm{U}}+m_{^{1}_{0}\mathrm{n}}-m-m_{^{92}_{36}Kr}-3m_{^{1}_{0}\mathrm{n}}\right)\cdot c^2$
30	**D**	$N=N_0e^{-\lambda t}$ $\left(5-3\right)\times10^{12}=5\times10^{12}e^{-\left(1.15\times10^{-8}\right)t}$