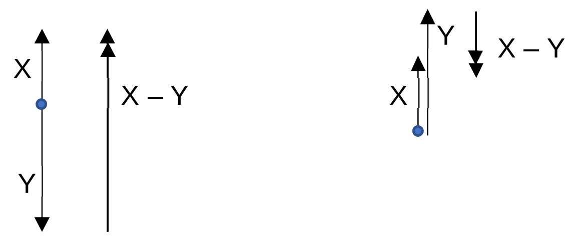
Suggested solutions to 2022 A-Level H2 Physics Paper 1

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

Q	**Ans**	**Working**
1	**A**	 Therefore as Y is rotated through 180°, the magnitude of X – Y gets smaller.
2	**C**	Vertical velocity: $s_y = u_y t + \frac{1}{2}gt^2$ $0 = u_y(2) + \left(\frac{1}{2}\right)(-9.81)(2)^2$ $u_y = 9.81 \text{ m s}^{-1}$ Horizontal velocity: $s_x = u_x t$ $100 = u_x(2)$ $u_x = 50 \text{ m s}^{-1}$ Angle: $\theta = \tan^{-1}\left(\frac{9.81}{50}\right) = 11.1^o$

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<td>3</td>
<td>B</td>
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Let the mass of P be m_P and the mass of Q be m_Q.

Since collision is elastic, relative speed of approach is equal to relative speed of separation,
"$u_P - u_Q = v_Q - v_P$"

$2 - 0 = v - (-0.50)$

$v = 1.5 \text{ m s}^{-1}$

By conservation of momentum,
$m_P(2.0) + 0 = m_P(-0.50) + m_Q v$

$m_P(2.5) = m_Q(1.5)$

$\frac{m_P}{m_Q} = \frac{1.5}{2.5} = 0.60$
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<tr>
<td>4</td>
<td>B</td>
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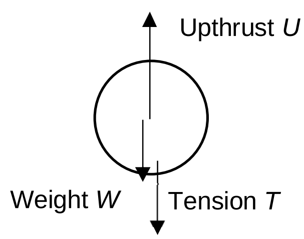

Since the buoy is in equilibrium,

$$U = W + T$$

$$V_{submerged}\rho g = mg + T$$

$$\left(\frac{1}{2}\right)\left(\frac{4}{3}\pi(0.5)^3\right)(1030)(9.81) = (200)(9.81) + T$$

$$T = 683 \text{ N}$$
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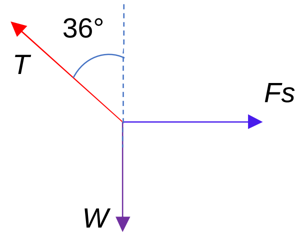
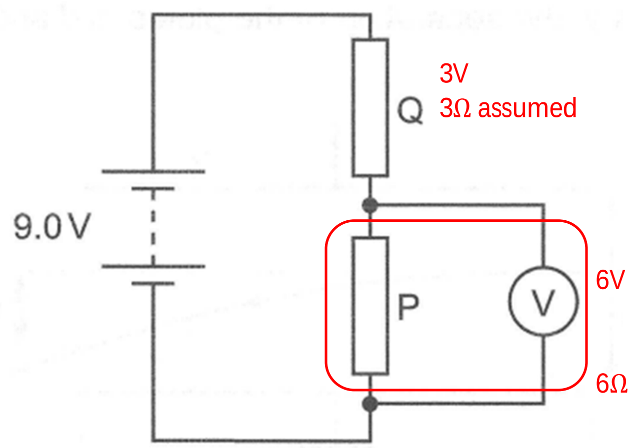
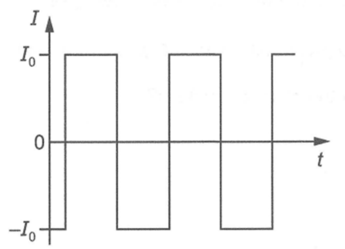
5	**D**	Forces acting on mass:  *Fs* = *kx* = 25 (0.060) = 1.5 N Resolving forces horizontally *T* sin 36= 1.5 ------(1) Resolving forces vertically *T* cos 36 = *W* ------(2) (1)/(2): tan 36 = 1.5/*W* Hence, *W* =2.1 N
6	**C**	$g = G\frac{M}{r^2}$ $9.81 = 6.67\times10^{-11}\frac{M}{\left(6.37\times10^{6}\right)^2}$ $M = 5.968\times10^{24}$ kg $density = \frac{M}{Volume} = \frac{5.968\times10^{24}}{\frac{4}{3}\pi\left(6.37\times10^{6}\right)^3} = 5510\text{ kg m}^{-3}$
7	**B**	Work done against air resistance = loss in gravitational potential energy Height of pendulum at 2nd oscillations $h = 0.60e^{-0.10(2)} = 0.491\text{ m}$ Hence, $\Delta h = 0.600 - 0.491 = 0.109$ m Loss in GPE $= mg\Delta h = 0.40(9.81)(0.109) = 0.43$ J
8	**C**	$v = r\omega$ $\omega = \frac{2\pi}{T}$ Angular velocity *ω* is independent of distance from centre of the disc.
9	**C**	A and B are incorrect. The orbital period is independent of the mass of the satellite as it is given by Kepler's Third Law: $T^2 = \frac{4\pi}{GM}r^3$ Where *M* is the mass of the planet. D is incorrect. The geostationary satellite has the same angular velocity as the point on Earth below it, but it has much higher linear velocity than the point on Earth below it. For instance, the linear speed of a point on the Equator is about 465 m s^{-1} whereas the linear speed of a satellite in geostationary orbit is 3075 m s^{-1}.

10	**D**	The resultant gravitational potential at P is the scalar addition of the potentials of each mass at that point. The combined gravitational potential at point P is $\phi = \phi_M + \phi_{4M}$ $= -\dfrac{GM}{\frac{d}{2}} - \dfrac{G(4M)}{\frac{d}{2}}$ $= \dfrac{-10GM}{d}$
11	**A**	The relationship between the r.m.s. speed of gas molecules and the absolute (Kelvin) temperature is given by $\frac{1}{2}m < c^2 >= \frac{3}{2}kT$ Where *m* is the mass of a molecule, *c* is the RMS speed, *k* is the Boltzmann constant and *T* is the absolute temperature. Hence, dividing the equations gives $\dfrac{c_{r.m.s2}}{c_{r.m.s1}} = \dfrac{\sqrt{T_2}}{\sqrt{T_1}}$ $\dfrac{c_{r.m.s2}}{350^2} = \sqrt{\dfrac{(160+273)}{(80+273)}}$ $c_{r.m.s2} = 387 \text{ m s}^{-1}$
12	**C**	The average kinetic energy of a gas molecule is given by $\frac{1}{2}m < c^2 >= \frac{3}{2}kT$ Therefore the total kinetic energy of the gas molecules will be this expression multiplied by the number of molecules, *N* Total $E_k = \frac{3}{2}NkT = \frac{3}{2}nRT$ *notice that $NkT = nRT$ from the ideal gas equation $PV = nRT = NkT$ The pressure, volume and temperature of the gas initially is given by $P_1V_1 = nRT$ Since temperature and the number of moles of the gas remains constant, that means the total kinetic energy of the gas is also constant and is given by Total $E_k = \frac{3}{2}nRT = \frac{3}{2}P_1V_1 = \frac{3}{2}(1\times10^5)(0.01) = 1500$ J
13	**B**	Energy converted to thermal energy = ½ (1/2 mv^2) mcΔθ= ¼ m v^2 Δθ = $\dfrac{v^2}{4c}$
14	**C**	From the graph, $x = 0.30\,sin(\frac{2\pi}{5.0}t)$ $x = 0.30\,sin(1.25t)$ $v = \dfrac{dx}{dt} = 0.38\,sin(1.3t)$
15	**A**	Option A is simply a case of supplying a bigger current to increase the amplitude of oscillation. No driving frequency is involved.

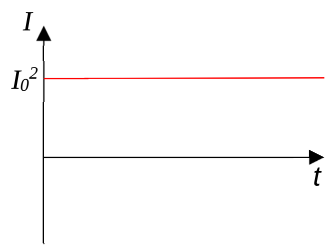
16	**D**	From diagram 1, $\lambda = 0.8m$ From diagram 2, T=0.2s $v = f\lambda$ Since $= \frac{1}{0.2} \times 0.8 = 4.0ms^{-1}$
17	**B**	X and Y are adjacent anti-nodes i.e. half a wavelength apart. Hence wavelength = 2 x 5.0 = 10 cm From the CRO, period = 6 div x 0.050 ms = 0.30 ms Hence frequency = 1/period = 3.3 kHz
18	**B**	$x = \frac{\lambda D}{a}$. For same D of 15 m, the largest $\frac{\lambda}{a}$ ratio will give the larges maxima apart.
19	**A**	$a = \frac{F}{m} = \frac{eE}{m} = \frac{eV}{md}$ Considering horizontal component of the motion $y = vt$ $t = \frac{y}{v}$ Considering vertical component of the motion $x = \frac{1}{2}at^2 = \left(\frac{eV}{2md}\right)\left(\frac{y}{v}\right)^2 = \frac{eVy^2}{2mdv^2}$
20	**A**	$I = nAvq = n\left(\pi\frac{d^2}{4}\right)vq$ Across the wire, the current I, charge density n, and charge q (elementary charge) will be constant. Hence $v \propto \frac{1}{d^2}$

21	**D**	 1. The pd across resistor Q is 3V 2. Assume a resistance of 3Ω for resistor Q. 3. Then the combination of P and voltmeter must be 6Ω , by potential divider principle. 4. Since P and the voltmeter have the same resistance and are in parallel, so P and the voltmeter would each be 12Ω. 5. Thus $\frac{\text{resistance of the voltmeter}}{\text{resistance of Q}} = \frac{12}{3} = 4$
22	**B**	Since there is no deflection on the galvanometer, the potential difference across 65 cm of the resistance wire is equal to the e.m.f. of the cell. e.m.f. = pd across 65 cm of wire = $0.65 \times 14.3 = 9.295 = 9.3\ V$
23	**C**	The two concepts in this question are: 1. Parallel currents attract each other, antiparallel currents repel each other. 2. The magnetic forces of one wire on the other are equal in magnitude and opposite in direction, since they are action-reaction forces according to Newton's third law. Hence, C is the answer.
24	**D**	The magnetic force on a current carrying conductor in a magnetic field is given by $F = BIL_{\perp}$ Meaning that the magnetic force is related to the *perpendicular* length of the current in the magnetic field. From the diagram, the horizontal component of the length (perpendicular to the field) is $PQ\cos\theta$ Thus the force is $F = BI(PQ)\cos\theta$ and is a maximum at the start and decreasing as a cosine function. Hence D is the answer.

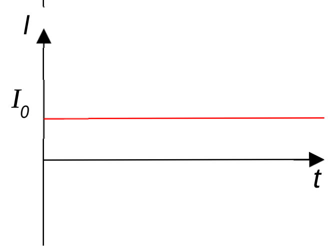
<table>
<tr><td>25</td><td>B</td><td>The magnetic flux through an area is given by
$\Phi = B_{\perp} . A$
Meaning that the flux is the product of the area and the component of the flux density perpendicular to the area surface.

According to the diagram, the vertical component of the flux density (perpendicular to the area) is $65 \mu T \ \sin 60^o$
Hence the flux is given by
$\Phi = 65 \times 10^{-6} \times \sin 60^o \times 12 \times 10^{-4}$
$= 6.75 \times 10^{-8}$ Wb</td></tr>
<tr><td>26</td><td>A</td><td>

To find the r.m.s value of the square wave, first we square the wave to obtain a straight line of value I_0^2.



Then we find the average value: but the average value of a horizontal constant value, is still the horizontal constant value.



Then, we square root to obtain the r.m.s. current, which is simply I_0.</td></tr>
<tr><td>27</td><td>B</td><td>Initial peak power $P_0 = I_0^2 R = \left(2^2\right)\left(20\right) = 80$ W

Initial mean power $\langle P \rangle = \frac{P_0}{2} = 40$ W
In a typical a.c. generator, the e.m.f. of the rotating coil is given by the rate of change of the flux linkage with time.
$\left|\varepsilon\right| = NBA\omega \sin\left(\omega t\right)$

The e.m.f. of the generator is thus proportional to the angular velocity of the generator, and so when the rotation speed is halved, the peak e.m.f. is halved and the peak current is also halved.
The new peak power is $P_0 = I_0^2 R = \left(1^2\right)\left(20\right) = 20$ W

The new average power is $\langle P \rangle = \frac{P_0}{2} = 10$ W</td></tr>
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28	**A**	The de Broglie wavelength is given by $\lambda = \dfrac{h}{p}$ The momentum and kinetic energy are related by $E_k = \dfrac{p^2}{2m}$ Hence the momentum is given by $p = \sqrt{2mE_k}$ And the wavelength is $\lambda = \dfrac{h}{\sqrt{2mE_k}}$ So when the kinetic energy is increased to 9E_k, the new wavelength is given by $\lambda_{new} = \dfrac{h}{\sqrt{2m9E_k}} = \dfrac{1}{3} \times \dfrac{h}{\sqrt{2mE_k}} = \dfrac{1}{3}\lambda$
29	**C**	$\Delta m = \left(\sum m_{nucleons}\right) - m_{nucleus}$ $= \left[83M_p + (212-83)M_n\right] - M$ $= 83M_p + 129M_n - M$
30	**C**	The energy released in the decay is given by $E = \left(\sum m_{\text{reactants}} - \sum m_{\text{products}}\right)c^2$ $= \left[238.1249 - (234.1165 + 4.0026)\right] \times 1.66 \times 10^{-27} \times c^2$ $= 8.665 \times 10^{-13}$ J