2022 H2 Prelim Paper 1 Solutions:

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

1 **B**

$$C_d = \frac{2F}{v^n \rho A} \Rightarrow C_d v^n \rho A = 2F$$

Unit of v = m s^{-1}

Unit of ρ = kg m^{-3}

Unit of A = m^2

Unit of F = kg m s^{-2}

$\Rightarrow$ $1 \times$ kg m^{n-1}s^{-n} = kg m s^{-2}

$\Rightarrow$ n = 2

2 **D** Radius of the object = $\dfrac{0.12}{6.4\times10^6}\times1.7\times10^6$ = 0.032 m = 3.2 cm

3 **A** Velocity of motorcyclist relative to car, $\boldsymbol{V_R} = \boldsymbol{V_M} - \boldsymbol{V_C}$

4 **C** Separation between P and Q is maximum when P is just hitting the ground.

Time for P to reach the ground is given by:

$$s = ut + \frac{1}{2}gt^2$$
$$= \frac{1}{2}gt^2$$
$$80 = 5t^2$$
$$t = 4 \text{ s}$$

Position of Q when P is hitting the ground:

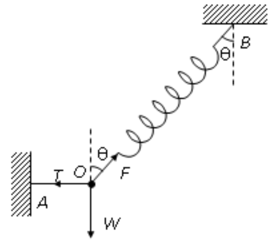
$$s = u(t-1) + \frac{1}{2}g(t-1)^2$$
$$= \frac{1}{2}g(t-1)^2$$
$$= 5\times(4-1)^2$$
$$= 45 \text{ m}$$

Hence, max. separation between P and Q = 80 – 45 = 35 m

5 **D** As the object is in static equilibrium, the resultant force of the three external forces acting on the object is equal to zero.

i.e. $\vec{T}+\vec{F}+\vec{W}=0$

and $\vec{F}+\vec{W} = -\vec{T}$



vertical: $F\cos\theta = W = mg$

horizontal: $F\sin\theta = T$

$\Rightarrow$ $T = mg\tan\theta$

At the instant the thread is suddenly cut, the force $\vec{T}$ is removed. Resultant force acting on the object $= \vec{F}+\vec{W}$

$= -\vec{T}$

Hence, acceleration of the object is direction II and magnitude of acceleration = $g\tan\theta$

6 **B** Total momentum of wagon remain unchanged because the vertical force by rain does not affect the horizontal momentum of the wagon.

The horizontal speed of wagon decreases because the amount of water in the wagon increases which increases the total mass of the system and so horizontal speed will decrease.

The kinetic energy of the system decreases using the equation ke = $\dfrac{p^2}{2m}$ since m increases while p remain constant.

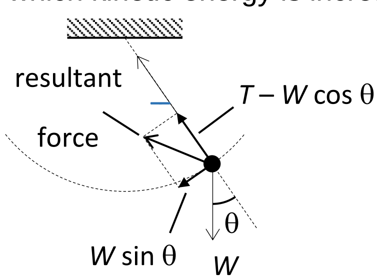
7 **C** The 3 forces, the 2 tensions in the string and the weight of the rod need to intersect at a point for it to be in equilibrium.

8 **C** Driving power = driving force x velocity = 500 x 40 = 20 MW

Power lost due to air resistance = air resistance x velocity = 200 x 40 = 8 MW

Rate at which kinetic energy is increasing = 20 – 8 = 12 MW

9 **B**



As the bob undergoes circular motion, there must be a resultant force acting on the bob in radial direction = centripetal force

$= T - W\cos\theta$

In the tangential direction, resultant force acting on the bob = $W\sin\theta$

Hence, the resultant force should be in direction Q.

10 **A** At the bottom of the hill, the net force = N - mg = centripetal force = ma

Hence, N = mg + ma > 0.

Therefore, the car can never lose contact at the bottom of the hill.

At the top of the hill, the net force = mg – N = ma

Hence, N = mg – ma

Therefore, the car will lose contact (feel weightless) when N < 0

$\Rightarrow$ g < a

$$\Rightarrow \quad g < \frac{v^2}{R}$$

$$\Rightarrow \ v > \sqrt{gR}$$

11 **D** $E_i = E_f$

$$\frac{1}{2}mv_e^{\ 2} + \left(-\frac{GMm}{R}\right) = 0 + 0$$

$$v_e = \sqrt{\frac{2GM}{R}} \alpha \sqrt{\frac{M}{R}}$$

12 **C** $W_{ext} = m\Delta\phi$

$$50 = 2.0\left(\phi_B - \phi_A\right)$$

$$\phi_B - \phi_A = 25 \text{ J kg}^{-1}$$

$$W_{ext} = m\Delta\phi$$

$$-60 = 2.0\left(\phi_C - \phi_B\right)$$

$$\phi_C - \phi_B = -30 \text{ J kg}^{-1}$$

$$W_{ext} = m\Delta\phi$$

$$1000 = 2.0\left(\phi_\infty - \phi_C\right)$$

$$\phi_C = -500 \text{ J kg}^{-1}$$

$\therefore \phi_B$ = -470 J kg^{-1} and ϕ_A = -495 J kg^{-1}

13 **A** Using $Q = mc\Delta\theta$,

Rate of heat removed is $\frac{Q}{t} = \frac{m}{t}c\Delta\theta$

$$\Rightarrow \frac{m}{t} = \frac{\left(\frac{Q}{t}\right)}{c\Delta\theta} = \frac{\left(\frac{4.0\times10^{11}}{60\times60}\right)}{4200\times8} = \frac{4.0\times10^{11}}{4200\times8\times60\times60} \text{ kg s}^{-1}$$

14 **C** For the grain of sand,

At eqm: a = 0
N = mg

At $x = +x_o$,
mg – N = ma
N = mg – ma = mg – mg = 0

At $x = -x_o$,
N – mg = ma
N = mg + ma = mg + mg = 2mg

15 **D** $x = x_0 \sin\omega t$

$= 3.0\sin\left(\frac{2\pi}{2.0}\right)0.25$

$= 2.1\text{ m}$

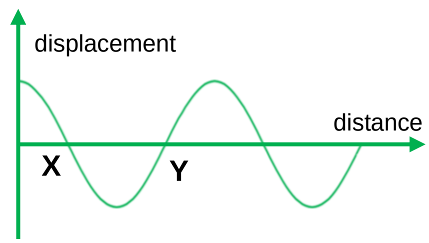
Total distance travelled = 3.0 + 2.1 = 5.1 cm

16 **A** $phase\ difference = \frac{0.22\sin 25^o}{1.7} \times 2\pi = 0.34\ rad$

17 **C** A is incorrect — At X, the air pressure is maximum

B is incorrect — It is a progressive wave not a standing wave.

C is correct — At X, the air molecule is moving to the right.



D is incorrect — At Y, equilibrium position, the air molecule has the highest speed.

18 **C** $f = \frac{v}{d}$

$10 = \frac{2.0}{d},\ d = 0.20\ m$

$\lambda = 2d = 0.40\ m$

Distance moved from initial position at M to second minimum intensity = 3(1/4 λ) = 0.30 m

19 **A** ke = $\frac{1}{2}mv^2 \propto v^2$

using $v^2 = 0 + 2ax$ $\Rightarrow v^2 \propto x \Rightarrow v \propto \sqrt{x}$ and ke $\propto x$, so quantity Y is speed v

E field is uniform inside the parallel plates, electric force is constant.

Electric potential energy, U =eV decreases linearly with x since e is negative and V is increasing linearly from -V to 0.

20 **C**

By potential divider method, the p.d. across internal resistance is $E\frac{(\frac{r}{2})}{R+\frac{r}{2}} = E\frac{r}{2R+r}$

Fraction of Power = $\frac{P_r}{P_{total}} = \frac{IV_r}{IV_{total}} = \frac{V_r}{E} = \frac{r}{2R+r}$

21 **B** D_1 is reversed biased, so pd across it is -E and pd acorss R_1 is 0 V

22 **D** For steady current,

$$P = I^2 R$$

$$For\ half - wave\ rectified\ ac,$$

$$P = \left(\frac{I_o}{2}\right)^2 \left(\frac{1}{2}R\right) = I^2 R$$

$$I_o = \sqrt{8}I = 2.8I$$

23 **B** By right hand grip rule, magnetic flux density at O due to P and Q points in direction of C.
Magnetic flux density due to R and S points in direction of A.
Hence resultant magnetic flux density at point O is in direction of B.

24 **A** The point charge's velocity is parallel to resultant magnetic flux density at the centre of the two wires. Thus magnetic force is zero.

25 **D**

$$\varepsilon = \frac{(2)(50)(30\times10^{-4})(4.0\times10^{-4})\sin 60^0}{0.60}$$

$$= 1.7\times10^{-4}\ \text{V}$$

26 **A** Since inner loop experiences decreasing flux linkage, current in the inner wire will flow in the same direction as that in the outer wire to oppose this deceasing flux linkage (Lenz's law).

Since the rate of decrease of current with time is constant, the rate of decrease of B and hence flux linkage is constant, hence e.m.f. induced in inner loop is constant and the current in the inner loop is constant.

27 **D** Velocity decreases → de Broglie's wavelength increases → sin θ increases→ larger diameter of circles

28 B Using Einstein's Photoelectric Equation,

hf = Φ + eV_s

3.5×10^{-19} = Φ + $(1.6 \times 10^{-19})(0.25)$

Φ = 3.1×10^{-19} J

29 **C** Total BE before reaction = 7.59 (235) = 1783. 65 Mev
Total BE after reaction = (8.26 x 121) + (8.52 x 113) = 1962 MeV
Change in BE = +179 MeV, manifested as the energy released (products are more stable)

30 B

$$\frac{A - X}{A_0 - X} = \left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}}$$

$$\frac{34 - X}{100 - X} = \left(\frac{1}{2}\right)^{\frac{20}{10}} = \frac{1}{4}$$

$X = 12$ Bq