2023 H2 Prelim Paper 1 Solutions:

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

1 **D**

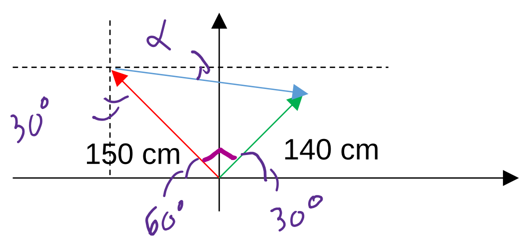
$$v=\frac{s}{t}=\frac{(385-115)}{(3.50-1.50)}=\frac{270}{2.00}=135\ mm\ s^{-1}$$

$$\frac{\Delta v}{v}=\frac{\Delta s}{s}+\frac{\Delta t}{t}$$

$$\frac{\Delta v}{135}=\frac{(1+1)}{270}+\frac{(0.02+0.02)}{2.00}$$

$$\Delta v=3.7=4\ mm\ s^{-1}$$

2 **D**



Magnitude of 2nd displacement = $\sqrt{150^2+140^2}=205\ cm$

At a direction α = 90 – 30 – $\tan^{-1}$ (140/150) = 17° below x axis or 343° anticlockwise to +x axis

3 **B**

At t = 0 s,

1.2 x 10^5 = 2(1.0 x 10^5) a

a = 0.60 m s^{-2}

At t = 20 s,

v = at = 0.60 x 20 = 12 m s^{-1}

back carriage moves with constant speed of 12 m s^{-1}, so in another 20 s, distance moved

= 12 x 20 = 240 m

front carriage now has acceleration of 1.2 m s^{-2}. In another 20 s,

s = ut + ½ at^2

s = 12 (20) + ½ (1.2)$(20)^2$ = 480 m

distance between front and back carriage = 480 - 240 = 240 m

4 **B** Ball A:

$h = \frac{1}{2} gt^2 \rightarrow$ time of flight $t = \sqrt{\frac{2h}{g}}$

$x_A = (2v)t = 2v\sqrt{\frac{2h}{g}}$

Ball B:

$2h = \frac{1}{2} gt^2 \rightarrow$ time of flight $t = \sqrt{2}\sqrt{\frac{2h}{g}}$

$x_B = vt = v\sqrt{2}\sqrt{\frac{2h}{g}}$

$$\frac{x_A}{x_B} = \frac{2}{\sqrt{2}} = \frac{\sqrt{2}}{1} = 1.41$$

5 **A** Consider the whole system,

$F - 6f = 6Ma$

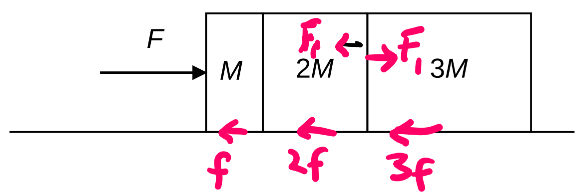
$a = \frac{F - 6f}{6M}$

Let the force that $3M$ acts on $2M$ be F_1.

Consider Newton's 2nd law on $3M$,

$F_1 - 3f = 3Ma$

$F_1 = 3M\left(\frac{F - 6f}{6M}\right) + 3f = \frac{F}{2}$



6 **A** Apply COM to the collision:

(5.0)(200) = (5.0 + 95) u

u = 10 m s^{-1}

Apply COE after collision:

½ (100) (10^2) = (100)(9.81) H

H = 5.1 m

7 **C** The 3 lines of action of the forces should coincide at a point.

8 **D** For each mass, Tension + Upthrust = Weight ⇒ Tension = Weight - Upthrust

Since rod is horizontal, tension is the same for both P and Q

Upthrust = Vρg is greater for P since liquid X is denser.

So weight of P is greater to get the same tension as Q.

9 **D** Let T be the tension in the string.

For vertical equilibrium of mass,

$T\cos 30.0^0 = mg$ (1)

For horizontal circular motion of mass,

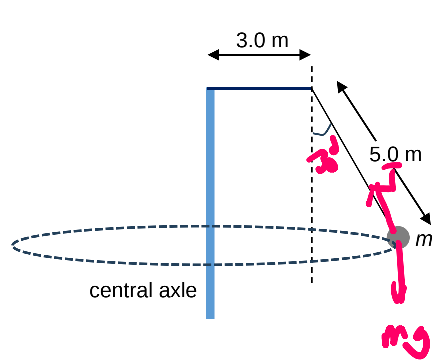
$T\sin 30.0^0 = mr\omega^2$ (2)

$\frac{(2)}{(1)} \rightarrow \tan 30.0^0 = r\omega^2/g$

$\tan 30.0^0 = (3.0 + 5.0\sin 30^0)\omega^2/9.81$

$\omega = 1.01$ rad s^{-1}

Time for one revolution $T = \frac{2\pi}{\omega} = 6.2$ s.



10 **C** Apply Newton 2[nd] law:

Along tangent of circular path,

$$F - mg\sin\theta = 0$$

Along the radial direction,

$$T - mg\cos\theta = mr\omega^2$$

Thus $T = mr\omega^2 + mg\cos\theta$*, so T varies with cos* θ

Note: Tension is largest at lowest point and smallest at highest point in a vertical circle.

11 **D** At point P,

$$\Phi_P = \left(-\frac{GM}{r/3}\right) + \left(-\frac{GM_B}{2r/3}\right)$$

$$= -\frac{G}{r}(3M + 1.5M_B)$$

At point Q,

$$\Phi_Q = \left(-\frac{GM}{2r/3}\right) + \left(-\frac{GM_B}{r/3}\right)$$

$$= -\frac{G}{r}(1.5M + 3M_B)$$

$$\Phi_Q = 1.25\Phi_P \text{, so}$$

$$(1.5M + 3M_B) = 1.25(3M + 1.5M_B)$$

$\Rightarrow M_B = 2M$

12 **D** Consider the forces on the satellite:

$$\frac{GMm}{r^2} = mr\omega^2 \quad \Rightarrow \quad \omega^2 \propto \frac{1}{r^3}$$

So when r decreases, both gravitational force on the satellite and the its angular velocity increase. So A and B are wrong statements.

Consider the various energies associated with an orbiting satellite:

$$KE = +\frac{GMm}{2r}, \quad GPE = -\frac{GMm}{r}$$

So when radius r decreases, KE increases while GPE decrease. So only D is correct.

13 **B** $10 = \dfrac{mc\Delta\theta}{t} + h$ –(1) where h is rate of heat loss to surroundings

$18 = \dfrac{3mc\Delta\theta}{t} + h$---(2) Solving (1) and (2) gives h = 6.0 W

14 **B** At constant P, V α T. When cooled, T decreases, so V decreases. Since gas undergoes compression, work is done on the gas. W = +ve

When T decreases, ΔU = -ve,

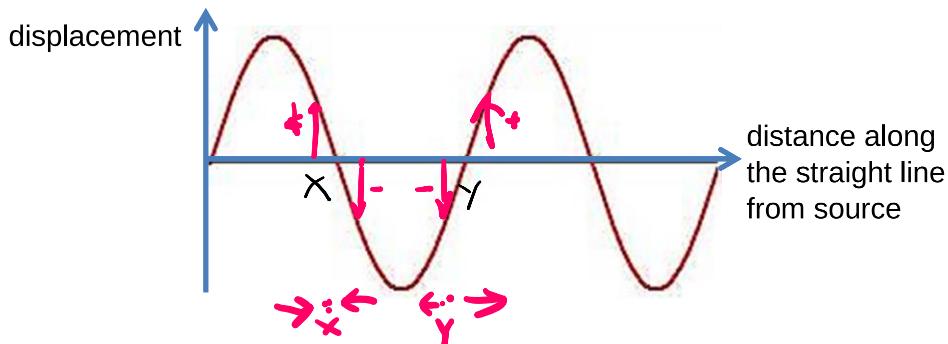
according to 1st law of thermodynamics $\Delta U = q + W$

-ve = q + (+ve) $\Rightarrow$ q must be -ve

15 **D** Given x_o = 0.030 m, from graph $\rightarrow$ period T = 2.0 s

Max v = $x_o \omega$ = 0.030 x (2π/2.0) = 0.094 ms^{-1}

16 **B**



At X, the two neighbouring particles are moving towards the particle at X, so it is a compression region . At Y the two neighbouring particles are moving away from the particle at Y.

17 **A** Rayleigh's criteria, minimum angle of resolution $\theta = \lambda/b$.
size of the pupil ≈ slit width b.
If b increases, θ decreases.
(If θ is small, images are easily resolved.)

18 **A** When the two polarisers are parallel($\theta = 0$), the intensity of emergent beam is I_0
When Q is rotated at angle θ, the intensity of emergent beam is reduced by 30%, which means final intensity should be $0.70I_0$. Appy Malus Law,

$$0.70I_0 = I_0 \cos^2 \theta$$

In the first quadrant, $\theta = 33°$

In the third quadrant, $\theta = 180° + 33° = 213°$

19 **D** The electric field within the conductor will be zero(since no net charge/equipotential inside a conductor) while the external regions will still have a uniform electric field pointing from positive to negative plate.

20 **B** $R = \rho L / A$, $R = V / I$

$V/I = \rho L / A$

$L = VA / I\rho$

$= 240\ [\pi(3.0 \times 10^{-4})^2] / (2.0 \times 1.4 \times 10^{-6})$

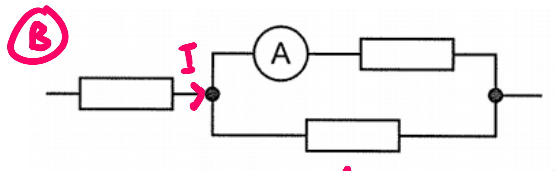
$= 24$ m

21 **B** A: $I_A = V/R$

B: $I_A = V/3R$

C: $I_A = V/R$

D: $I_A = V/2R$



$V = I(R + R/2) \rightarrow I = \frac{2V}{3R} \Rightarrow I_A = \frac{I}{2} = \frac{V}{3R}$

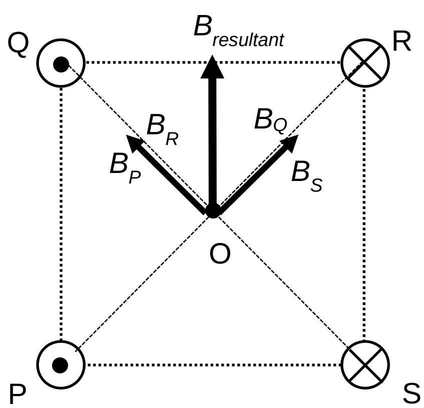
22 **A** $V = E - Ir$

When current $I = 0$, $V = E = 2.5$V

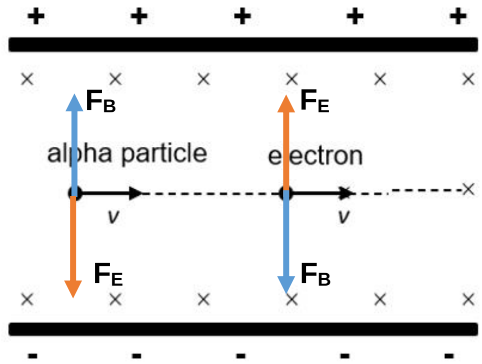
$0.9 = 2.5 - 0.80\ r$

$r = 2.0\ \Omega$ or use gradient of graph = $-r$

23 **A** Apply RH Grip Rule to determine the direction of B-field at O due to the currents flowing in a straight wire at P, Q, R and S respectively. Vector sum of the B fields gives direction A.



24 **A**



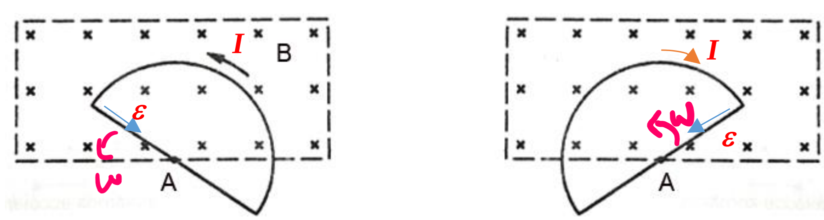
electron passes undeflected so

electric force F_E = magnetic force F_B

$$\not{q}E = B\not{q}v$$

conditions for passing through undeflected does not depends on mass or charge so outcome is the same.

25 **C** Similar to Faraday's homopolar generator. The induced current $I = \varepsilon/R = B\pi r^2 f/R$, which is **a constant value** when r and f are kept constant. However the direction of current changes clockwise or anticlockwise, depending on which radii is cutting the flux(use Fleming RH rule).



26 **C** de Broglie wavelength λ = h/mv, so $\lambda \propto 1/m$ for same speed v.

Since mass of electron is much smaller than proton, $\lambda_e > \lambda_p$

For single slit diffraction pattern, $b\sin\theta = \lambda$, so $\sin\theta \propto \lambda$, → diffraction angle for electron is much larger than protons.

27 **B** Electrons: $dN_e/dt = I / e = 2.0\times10^{-6} / 1.6\times10^{-19}$

Photons: $dN_p/dt = P / E = 0.31\times10^{-3} / 3.11\times1.6\times10^{-19}$

Ratio = 0.020

28 **C** $p = mv = (9.11 \times 10^{-31})(1.50\times 10^{6})=1.37 \times 10^{-24}$ kg m s^{-1}

$\Delta p = 0.2\%$ x p = 0.002 p = $0.002(1.37 \times 10^{-24}) = 2.73 \times 10^{-27}$ kg m s^{-1}

$\Delta x = h/(\Delta p) = 6.63 \times 10^{-34} / (2.73 \times 10^{-27}) = 2.4 \times 10^{-7}$ m

29 **A** Energy released = BE of products − BE of reactants

$= (8.32 \times 136) + (8.58 \times 98) - (7.60 \times 235) = 186$ MeV

30 **D** Initial true count rate = 90 -10 = 80

No of half lives = 12/24 = 0.5

C = $80(1/2)^{0.5}$ = 57 min^{-1}

Final count = 57+10 = 67 min^{-1}