

30 An electron moves with a constant velocity of $1.5 \times 10^6 \text{ m s}^{-1}$. If its momentum is measured to a precision of 0.2%, what is the uncertainty associated with its position?

A $2.4 \times 10^{-7} \text{ m}$

B $3.9 \times 10^{-8} \text{ m}$

C $1.2 \times 10^{-10} \text{ m}$

D $1.9 \times 10^{-10} \text{ m}$

2020 H2 Prelim Section A Solutions:

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

1 D Electric field strength $E = F/q$, units = $NC^{-1} = kgms^{-2}(As) = kg\ ms^{-1}A \rightarrow 4$ base units

Power $P = Fv$, units = $kgms^{-2}\ ms^{-1} = kgm^2\ s^{-3} \rightarrow 3$ base units

2 A From graph, angular deflection of the needle increases at a decreasing rate as the current increases. Hence, the separation of the current scale will decrease as the current increases.

3 C Constant acceleration a

$$\text{So } v^2 = u^2 + 2as \Rightarrow as = \frac{1}{2}(v^2 - u^2)$$

$$\text{At Y, } v_Y^2 = u^2 + 2a(s/2) = u^2 + as = u^2 + \frac{1}{2}(v^2 - u^2) = \frac{1}{2}(u^2 + v^2)$$

4 C During fall in air, weight of ball - viscous force = ma

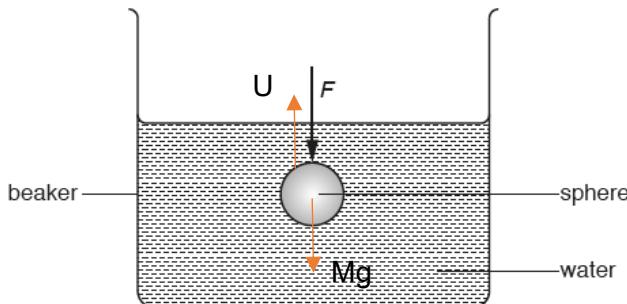
Initially the ball is accelerating at a decreasing rate since viscous force increases with speed.

At terminal speed, weight of ball - viscous force, i.e $mg = kv$

If mass m is less, terminal speed is less.

The gradient of $s - t$ graph gives the velocity v . answer is C.

- 5 D Let F be the upward force by 3m on the system of $(m + 5m)$.
 F_{net} on system of $(m + 5m) = F - 6mg$
 $F - 6mg = 6ma$
 $F = 6mg + 6ma$
By Newton's 3rd law, magnitude of force m exerts on 3m = $F = 6mg + 6ma$
- 6 A Volume of sphere = $M/\rho = 0.75/650 = 1.15 \times 10^{-3} \text{ m}^3$



For equilibrium,

$$F + Mg = U$$

$$\begin{aligned} F &= U - Mg = V\rho_w g - Mg \\ &= 1.15 \times 10^{-3} \times 10^3 \times 9.81 - 0.75 \times 9.81 \\ &= 3.9 \text{ N} \end{aligned}$$

- 7 D COM is observed in the x- and y-direction.

$$\text{x-direction: } p = p_x \cos\theta + p_y \cos\alpha$$

$$\text{y-direction: } 0 = p_x \sin\theta - p_y \sin\alpha$$

- 8 D Extension $x = F/k$

Both string are stretched by same force 80 N.

$$x_1 = 80/4000 = 0.02 \text{ m}, x_2 = 80/2000 = 0.04 \text{ m}$$

$$\text{ratio of pe} = \frac{1}{2}Fx_1 / \frac{1}{2}Fx_2 = x_1/x_2 = 1:2$$

- 9 A During 2.0 s, displacement $s = \text{area under v-t graph} = \frac{1}{2} \times 2.0 \times 0.5 = 0.5 \text{ m}$

$$\text{Work done by force} = Fs = 3.0 \times 0.5 = 1.5 \text{ J}$$

- 10 C The resultant of 160 N and 120 N should provide the horizontal centripetal force.

$$\text{Resultant force} = \sqrt{(160^2 - 120^2)} = 105.8 \text{ N}$$

$$\text{Resultant force} = ma$$

$$105.8 = (120/9.81) a \Rightarrow a = 8.65 \text{ ms}^{-2}$$

- 11 A Gravitational potential increases towards infinity. -20 MJ kg^{-1} is at a higher point than -30 MJ kg^{-1} . So mass is moving away from Earth.
change in GPE = mass x change in potential = $1500(-20+30) \times 10^6 = 15 \text{ GJ}$

- 12 C** From graph, time to melt completely = 11×60 s

$$\text{Power} \times \text{time} = mL$$

$$0.25 \times 10^3 \times 11 \times 60 = m \times 3.3 \times 10^5$$

$$m = 0.5 \text{ kg}$$

- 13 A** A is correct. Since $\Delta U = Q + W \Rightarrow \Delta U$ can be increased by Q and/or W.

B is wrong because internal energy $U = \text{sum of ke and pe of molecules of a system}$. Only ke depends on temperature but pe depends on intermolecular forces of attraction and separation between molecules.

C and D are wrong statements, same explanation as B.

Note: if the system is an ideal gas, then B, C and D are correct statements.

- 14 B** Amplitude = 5.0 cm

$$a = -\omega^2 x, 10 = (2\pi/T)^2 (0.050) \rightarrow T = 0.44 \text{ s}$$

- 15 A** At displacement = $\frac{A}{2}, u^2 = \omega^2 \left[A^2 - \left(\frac{A^2}{4} \right) \right]$

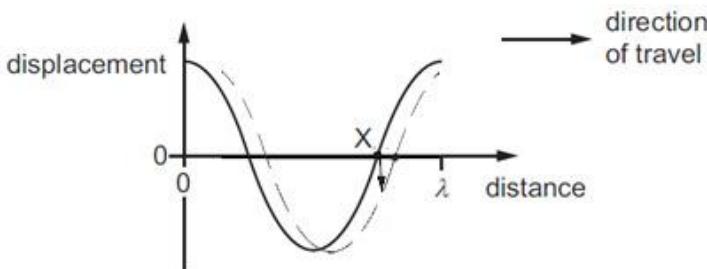
$$\text{At displacement} = 0, v^2 = \omega^2 A^2$$

$$\text{Therefore } v = \frac{2}{\sqrt{3}} u$$

- 16 A** From graph, resonant freq, $f_o = 1.5 \text{ Hz}$, amplitude $x_0 = 16.4 \text{ cm} = 0.164 \text{ m}$.

$$\text{Hence } v_{\max} = \omega x_0 = (2\pi f_o) x_0 = 1.55 \text{ m s}^{-1}. \text{ Light damping as curve has sharp peak}$$

- 17 C** The next waveform is shifted to the right as shown. X is travelling downwards from equilibrium position.



- 18 A** First minima position: $b \sin \theta = \lambda$

$$0.010 \times 10^{-3} \times 0.05 = \lambda$$

$$5.0 \times 10^{-7} \text{ m} = \lambda$$

- 19 A** Field lines should be perpendicular to the metal plate surfaces.

At the bottom, the distance between the two plates is the shortest.

At the top, the distance between the two plates is the longest.

Hence, the rate of change of potential will be highest at the bottom, and lowest at the top.

Since $E = -dV/dx$, field strength is strongest at the bottom and is represented by the closer field lines.

- 20 A Resistance is V/I which is the same for the diode graph and filament lamp at 1.2 V where the two graphs intersect.

21 C $E=Pt=40 \times 3=120 \text{ J}$

22 C
$$P = I^2 R = I_{rms}^2 \frac{R}{4}$$

$$I_{rms} = 2I \quad \Rightarrow I_o = 2\sqrt{2}I$$

- 23 B S experiences attractive forces towards P and R (Like currents) but since R has a higher current, net force is towards R. Q has a current in the opposite direction so S experiences another force away from Q. Resultant force is downwards.

24 A
$$\begin{aligned} F_B &= N \times (BIL \sin\theta) = 100 \times 0.55 \times 1.6 \times 0.1 \\ &= 8.8 \text{ N} \end{aligned}$$

$$\begin{aligned} \text{Torque} &= 8.8 \times 0.05 \\ &= 0.44 \text{ N m} \end{aligned}$$

Using FLHR, direction of force on right edge is moving into the plane of paper.

- 25 A

Let PQ be a straight conductor:

Using Fleming's right hand rule, current flows from P to Q. As P and Q behaves like a battery, current flows from low to high potential. Hence, P is of a lower potential.

- 26 B

- 27 C

Option A : Incorrect. If the frequency of light is sufficiently high, even at extremely low intensities there will be emission of photoelectrons.

Option B : Incorrect. From Einstein's photoelectric effect equation, there is not direct relationship between frequency and stopping potential. Increasing frequency will increase stopping potential but the relationship is not linear.

Option D: Increasing the intensity of the incident photons will not change the energy of each photon, it just increases the no. of photons per unit time incident on the metal. Hence, the energy of the photoelectrons emitted will not change as the interaction between each photon and electron remains the same.

- 28 C

$$eV = hf - hf_0$$

- 29 A

$$\lambda = h/p$$

$$p = mv$$

$$E = \frac{1}{2} mv^2 = eV$$

Hence p is proportional to $V^{1/2}$ and λ is proportional to $V^{-1/2}$

30 A

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

$$\Delta p = 0.002 p = 0.002(1.37 \times 10^{-24}) = 2.74 \times 10^{-27} \text{ kg m s}^{-1}$$

$$\Delta x = h / (2.74 \times 10^{-27}) = 2.41 \times 10^{-7} \text{ m}$$