2024 J2 Prelim P1

Q1	D	Q6	C	Q11	C	Q16	B	Q21	A	Q26	D
Q2	B	Q7	B	Q12	D	Q17	A	Q22	A	Q27	C
Q3	D	Q8	B	Q13	C	Q18	A	Q23	A	Q28	D
Q4	B	Q9	D	Q14	D	Q19	B	Q24	C	Q29	B
Q5	C	Q10	C	Q15	C	Q20	A	Q25	A	Q30	D

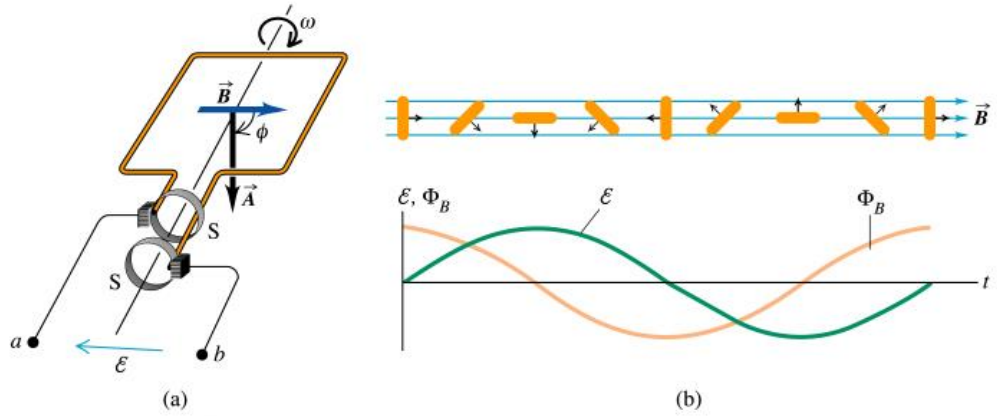
1.	**Ans: D** Option A is wrong. $F = ma \Rightarrow N \equiv \frac{kg}{ms^{-2}} = kg\ m\ s^{-2}$ Option B is wrong. $f = \frac{1}{T} \Rightarrow Hz \equiv s^{-1}$ Option C is wrong. $W = Fd \Rightarrow J \equiv N\ m$ Option D is correct. $F = BIL\sin\theta \Rightarrow B = \frac{F}{IL\sin\theta} \Rightarrow T \equiv \frac{kg\ m\ s^{-2}}{A\ m} = kg\ A^{-1}\ s^{-2}$
2.	**Ans: B** $\frac{\text{distance travelled between 0 to 20 s}}{\text{distance travelled between 5 to 15 s}}$ $= \frac{\text{distance travelled between 0 to 10 s}}{\text{distance travelled between 5 to 10 s}}$ $= \frac{\text{area under v-t graph from 0 to 10 s}}{\text{area under v-t graph from 5 to 10 s}}$ $= \frac{1}{0.75}$ $= 1.3$
3.	**Ans: D** Since the acceleration on the way up will be larger (air resistance and weight acting in the same direction) than the acceleration of the way down (air resistance and weight acting in opposite directions), the time taken on way up will be less.
4.	**Ans: B** $impulse = \frac{1}{2}(62)(0.21) = 6.51\ kg\,m\,s^{-1}$ $v = \frac{p}{m} = \frac{6.51}{0.150} = 43.4\,m\,s^{-1}$
5.	**Ans: C** $acceleration = \frac{(10)(9.81)}{10+12} = 4.459\,m\,s^{-2}$

	By considering the 12 kg block, tension = resultant force Hence, $tension = (12)(4.459) = 53.5N$
6.	**Ans: C** $\tan(3.8^\circ) = \frac{centripetal\ acceleration}{9.81}$ $centripetal\ acceleration = 0.65158\,m\,s^{-2}$ $\frac{v^2}{r} = 0.65158\,m\,s^{-2}$ $r = \frac{\left(\frac{57.8}{3.6}\right)^2}{0.65158} = 396\,m$
7.	**Ans: B** For satellite in geostationary orbit, period = 24 hours = 86400 s $\omega = \frac{2\pi}{86400}$ gravitational force provides for centripetal force $\frac{GMm}{r^2} = mr\omega^2$ $r = \left(\frac{GM}{\omega^2}\right)^{\frac{1}{3}} = \left(\frac{(6.67\times10^{-11})(5.97\times10^{24})}{\left(\frac{2\pi}{86400}\right)^2}\right)^{\frac{1}{3}} = 4.2227\times10^7\,m$ $\omega = \frac{v}{r}$ $v = \omega r = \left(\frac{2\pi}{86400}\right)(4.2227\times10^7) = 3071\,m\,s^{-1}$ Alternatively, a shorter method would skip calculating the radius *r*. $mr\omega^2 = \frac{GMm}{r^2}$ $r^3\omega^2 = GM$ $\times\omega^3$ *to both sides* $(r^3\omega^3)(\omega^2) = GM\omega^3$ $v^3\omega^2 = GM\omega^3$ $v = \sqrt[3]{GM\omega} = \sqrt[3]{(6.67\times10^{-11})(5.97\times10^{24})\left(\frac{2\pi}{24\times3600}\right)} = 3071\,m\,s^{-1}$

8.	**Ans: B** increase in GPE of space probe = $GPE_{final} - GPE_{initial}$ $= -\frac{GMm}{r_{final}} - \left(-\frac{GMm}{r_{initial}}\right) = (6.67\times10^{-11})(1.30\times10^{22})(5500)\left(\frac{1}{1.19\times10^{7}} - \frac{1}{(1.19+0.24)\times10^{7}}\right)$ $= 6.73\times10^{8}\ J$
9.	**Ans: D** Statement D is not an essential assumption of kinetic theory of gas and can be derived from pressure of a gas
10.	**Ans: C** heat gained by ice in melting + heat gained by 20 g of water (total mass of water) = heat lost by 130 g of water $0.020 \times 3.3 \times 10^5 + [0.020 \times 4.2 \times 10^3 \times (T - 0)] = 0.130 \times 4.2 \times 10^3 \times (50 - T)$ $6.6 \times 10^3 + 84\ T = 27.3 \times 10^3 - 546\ T$ $630\ T = 20700$ $T = 33\ °C$ distractor: T = 38 °C (heat gained by melted ice water omitted)
11.	**Ans: C** Resonance occurs when the natural frequency of water molecules matches the frequency of the incident microwave. By changing its frequency, resonance will not occur, resulting in smaller amplitude of vibration of water molecules and therefore, lesser amount of energy absorbed by the food for it to be cooked. To warm up the food faster, the water molecules need to vibrate more to transfer more energy to the food. This can be achieved by increasing the amplitude of the incident microwave which will result in more energy being transferred from the microwave to the water molecules.
12.	**Ans: D** **$I \propto 1/x^2$** $I_Q/I_P = (1/2)^2 = ¼$ $I_Q/I_P = (A_Q/A_P)^2 = (6 / A_P^2) = 1/4$ $A_P = 12.0\ \mu m$
13.	**Ans: C** At P, acceleration is maximum, OS represents two periods, Kinetic energies at Q and R are the same
14.	**Ans: D** To obtain a steady interference with minimum intensity at point P, both the sources must be coherent and be out of phase by π radians. Both sources can be of the same amplitude. The next minimum produced at Q corresponds to a path difference of 1 m and this should be equal to one wavelength. Thus, the wavelength of the waves must be 1 m and not 2 m.

15.	**Ans: C** Separation between the horizontal threads is determined by the vertical bright fringes. $\tan\theta = \frac{0.0548/2}{2.00} = 0.0137$ $\theta = 0.7849^{\circ}$ $d\sin\theta = m\lambda$ $d\sin 0.7849^{\circ} = 2(685\times10^{-9})$ ***d* = 1.00 x 10^{-4} m = 0.100 mm.** For comparison, the spacing of the vertical threads is determined by the horizontal bright fringes: $d\sin 0.7849^{\circ} = 1(685\times10^{-9})$ *d* = 5.00 x 10^{-5} m = 0.0500 mm.
16.	**Ans: B** Initially, since the oil droplet drops with a reduced acceleration, it means the electric force due to the two metal plates is acting in the opposite direction. $$W - F_E = ma$$ Subsequently, when the polarity is reversed, we have $$W + F_E = 7ma$$ Thus by subtracting the first expression from the second $$2F_E = 6ma$$ $$2\frac{qV}{x} = 6ma$$ $$q = \frac{3max}{V}$$
17.	**Ans: A** The electric field is directed upwards in order to produce an upward electric force to balance the downwards weight. Therefore, the lower plate will be at higher potential and upper plate at lower potential. Since the particle is positively charged, when it moves towards the upper plate (lower potential), its electric potential energy will decrease.
18.	**Ans: A** For NTC thermistor, as current increases, the amount of heat generated increases and the equilibrium temperature *T* increases. As *T* increases, bonded electrons break free from bonds, increasing the number of 'mobile charge carriers', hence decreasing resistance. Since resistance is the ratio of *V* to I, the graph should show an increasing ratio of I to *V*.

19.	**Ans: B** effective resistance of the outer most loop $= R\left(\frac{3\times 1}{3+1}\right) = 0.75R$ effective resistance across XY $= R(0.75+1+1) = 2.75R$
20.	**Ans: A** magnetic flux density at centre of coil Q, $B_Q = \frac{\mu_0 N I_Q}{2r} = \frac{\mu_0 I_Q}{2r}$ magnetic flux density at a distance 2*r* from wire P at centre of coil Q, $B_P = \frac{\mu_0 I_P}{2\pi d} = \frac{\mu_0 I_P}{2\pi(2r)}$ For the resultant magnetic field to be zero at the centre of coil Q, B_Q and B_P a the centre must be equal in magnitude and opposite in direction. $B_Q = B_P$ $\frac{\mu_0 I_Q}{2r} = \frac{\mu_0 I_P}{2\pi(2r)}$ $I_Q = \frac{I_P}{2\pi}$ $I_P = 2\pi I_Q$ Since B_Q is out of the page at the centre of coil Q, B_P must be into the page at the centre. Hence direction of current in wire P flows to the right.
21.	**Ans: A** Since the reading on the balance increased, there must be a downward force acting on the horseshoe magnet and an upward force on the wire according to Newton's 3rd law. Using Fleming's left hand rule, since magnetic force on wire is upwards and current is from Y to X, the magnetic field must be from A (North) to the opposite face (South)
22.	**Ans: A** As solenoid X moves away from Y, Y will experience a decreasing magnetic flux through it, therefore, the direction of the induced e.m.f. will be so as to create a magnetic field in the same direction to oppose the decrease. By right hand grip rule, the current will flow from N to M. Since the magnetic North pole for Y is facing the magnetic South pole for X, the force will be attractive in nature. This can also be explained by Lenz's law as the solenoid Y will need to be attracted so that the motion of solenoid X away from it can be opposed. Lastly, the rate of change of magnetic flux linkage will be decreasing as the magnetic flux density will not be dropping at a linear rate but follows an inverse cube relationship. Therefore current is diminishing.

23.	**Ans: A** 
24.	**Ans: C** $current = \frac{P}{V} = \frac{120000}{6000} = 20\,A$ $power\ dissipated\ in\ wire = (20)^2(3.0) = 1200\,W$
25.	**Ans: A** $x = x_0 \sin(\omega t),\ where\ \omega = \frac{2\pi}{T} = \frac{2\pi}{12.6}\ and\ x_0 = 1.5$
26.	**Ans: D** Option A is incorrect: Low intensity high frequency can result in photoelectric effect. Option B is incorrect: $hf - \Phi = eV_s$ $h(2f) - \Phi \neq e(2V_s)$ Option C is incorrect: This option is correct for **min frequency** so should have been *max* wavelength. Option D is **CORRECT**: Increasing intensity for a monochromatic light will increase the number of photons incident.
27.	**Ans: C** Using $\Delta x \Delta p \geq h$, $\frac{\Delta v}{v} \times 100 = 0.005$ $\Delta v = \frac{0.005}{100} \times 2.0 \times 10^6 = 100\ \text{m s}^{-1}$ $\Delta x \geq \frac{h}{\Delta(mv)} = \frac{h}{m\Delta v} = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 100}$ $= 7.278 \times 10^{-6}$ $= 7.3 \times 10^{-6}\ \text{m}$

28.	**Ans: D**
29.	**Ans: B** A a β^- emission will only cause proton number to increase by 1 but nucleon number to stay the same.
30.	**Ans: D** Since the radiation can penetrate aluminium, it cannot be alpha radiation which is least penetrative of all the radiation can be stopped by a sheet of paper. Since there is a magnetic field perpendicular to the diagram, the path is curved due to the magnetic force. The radius of the path is smaller on the left of the aluminium sheet, this can be attributed due to the particle losing speed after passing through it. Hence, it must have entered from Y and exits from X.