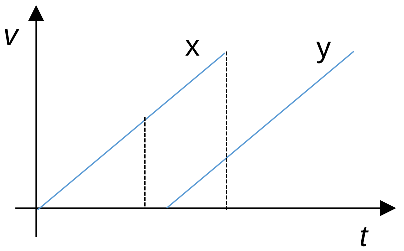
Solutions to J2 Preliminary Examination Paper 1

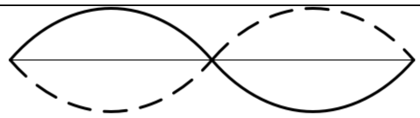
1	**A**
2	**D**
3	**B**
4	**D**
5	**A**
6	**C**
7	**B**
8	**C**
9	**B**
10	**D**

11	**C**
12	**A**
13	**B**
14	**D**
15	**C**
16	**C**
17	**D**
18	**B**
19	**A**
20	**B**

21	**D**
22	**C**
23	**B**
24	**A**
25	**A**
26	**A**
27	**C**
28	**B**
29	**C**
30	**D**

Qn	Key	guide
1.	**A**	Considering units of the equation, we have $s^2 = \frac{\text{kg m}^2}{\text{units of K}}$, so units of K = kg m^2 s^{-2} = (kg m s^{-2}) m = N m
2.	**D**	 Since air resistance is negligible, the gradient of both graphs will be the same. From the v-t graph, it can be seen that at any time, the difference in the area under graph for X and Y will be increasing hence the separation will be increasing.
3.	**B**	Note that the carriages and the engine have a common acceleration, say *a*. Let the mass of each carriage be *m*. Consider both carriages, Newton's 2nd law gives $T = (2m)a$, so $a = \frac{T}{2m}$ Consider the back carriage. Tension pulling the back carriage is then $ma = m\left(\frac{T}{2m}\right) = \frac{T}{2}$
4.	**D**	During acceleration, $W - mg = ma$, so $W = m(9.81 + 2.0)$ During deceleration, $mg - W' = ma$, so $W' = m(9.81 - 2.0)$ So $\frac{W'}{W} = \frac{9.81-2.0}{9.81+2.0} = 0.661$
5.	**A**	Since the same load is applied, for X, if extension is *L*, then extension for Y will be 2*L* For Z, the extension will be the greatest as the top two springs will stretch by the same amount of *L* while the lower spring will have twice the extension due to the weight being supported by only one spring
6.	**C**	Work done = 120 cos 37^o x 5.0 = 479 = 480 W
7	**B**	Initially, when no force is applied to the piston, force on piston by air in container = force on piston by air in atmosphere = pressure x area = $(100\times10^3)(3.5\times10^{-3})$ = 350 N $\frac{(100\times10^3)(3.5\times10^{-3})(80\times10^{-3})}{T} = \frac{(\text{new pressure})(3.5\times10^{-3})(160\times10^{-3})}{0.5T}$ new pressure = 25 kPa new force on piston by air in container = pressure x area = $(25\times10^3)(3.5\times10^{-3})$ = 87.5 N

		For piston to remain stationary, Force on piston by air in container + F = Force on piston by air in atmosphere 87.5 + F = 350 F = 260 N (262.5)
8	**C**	Let X be the gas compressed isothermally (no change in temp). There is heat exchange between the gas and the surroundings. Let Y be the gas compressed and is isothermally isolated from surroundings. There is no heat exchange between gas and the surroundings. For X: Since temperature does not change due to heat exchange between gas and the surroundings, $p_1V = p_2(0.5V)$, $p_2 = 2\ p_1$ For Y: Using pV = nRT, when V decreases, pressure increases and leads to larger speed of the molecules. This leads to higher temperature of gas. A: No heat is given to both gases during compression. B: Internal energy of Y is higher due to higher temperature of gas that leads to higher average KE. C: Since mass and volumes of gases are the same, there is no change in density of gases. D: Since work done on gases depends on the pressure and the change in volume and there is no information on how pressure varies for both gases during compression, the work done on gases may not be the same.
9	**B**	The following options are wrong. A: There is no thermal energy supplied to the system. C: If the air becomes hot, there should be increase in internal energy. D: The statement does not lead to the effect of higher temperature of gas.
10	**D**	Using $v = r\omega$, $\frac{dv}{dt} = \frac{dr}{dt}\omega$ Since $\frac{dr}{dt}$ and ω are constant, it should be a straight line graph for a graph of v against t.
11	**C**	Use v = u + at $0 = 45 - g_x(5.2)$ $g_x = 8.65\ \text{m s}^{-2}$ $g_y = \Delta\Phi/\Delta x = 6.0(4.0) = 1.5\ \text{m s}^{-2}$ $g_{y\ :}\ g_x = 1.5/8.65 = 0.17$
12	**A**	Using $E_k = \frac{Gm_E m}{2r}$, m_A is larger than m_B and since both satellites have same kinetic energy,

		Using total energy $= -\dfrac{Gm_E m}{2r}$, satellites A and B have the same total energy, (Option A is false) Orbital radius for satellite A is larger than that of satellite B. (Option B is true) Using T^2 is proportional to r^3, satellite A has a larger period (Option C is true) Since angular velocity is inversely proportional to T, satellite A as smaller angular velocity (Option D is true)
13.	**B**	Total energy of mass in S.H.M: $\dfrac{1}{2}m\omega^2 {x_0}^2 = \dfrac{1}{2}\left(\dfrac{8}{1000}\right)\left(2\pi(40)\right)^2\left(\dfrac{5}{1000}\right)^2$ $= 6.32 \times 10^{-3}$ J
14.	**D**	With increased damping, amplitude will generally be lower throughout and peak will shift left.
15.	**C**	
16	**C**	 $\lambda = L$ Points between two adjacent nodes are in phase. Points in adjacent segments are anti-phase.
17	**D**	Using $x = \dfrac{\lambda D}{a}$, $x = \dfrac{\left(600 \times 10^{-9}\right)(1)}{a}$ $2x = \dfrac{\left(400 \times 10^{-9}\right)D}{a}$ D = 3.00 m
18	**B**	Current in circuit, $I = \dfrac{V}{R} = \dfrac{10}{4.0} = 2.5$ A, Potential difference across connecting wires = 12 – 10.0 – (2.5)(0.20) = 1.5 V Power loss in connecting wires = (2.5)(1.5) = 3.75 W

19	**A**	Using $a = \frac{F}{m}$ and $F = Eq$, $\therefore a = \frac{Eq}{m}$ proton: $a_{proton} = \frac{Eq}{m}$ alpha particle: $a_{alpha} = \frac{E(2q)}{4m} = \frac{a_{proton}}{2}$ Using v = u + at, $v_{proton} = 0 + at$ $v_{alpha} = 0 + \frac{a}{2}t$ Ratio = 0.5
20	**B**	Electric potential decreases along the direction of electric field strength.
21.	**D**	By conservation of charges, $I_1 = I_2 + I_3$ ---- (1) Also for the parallel circuit, we note that $\frac{I_2}{I_3} = \frac{R_3}{R_2}$ ----- (2) Using (1) and (2) to eliminate I_2, (1) becomes $I_1 = I_3\left(\frac{R_3}{R_2}\right) + I_3$, or $I_1 = I_3\left(\frac{R_3}{R_2} + 1\right)$, giving $\frac{I_3}{I_1} = \frac{R_2}{R_2+R_3}$
22.	**C**	$B = \frac{\mu_0 I}{2\pi d}$ Since we want to find the distance at which the PEAK flux density would be, that would occur when the PEAK current is flowing through the circuit. $100 \times 10^{-6} = \frac{\mu_0\left(2000 \times \sqrt{2}\right)}{2\pi d}$ $d = 5.66$ m
23.	**B**	Current-carrying conductors will attract when currents are in same direction, but repel when in opposite directions. Hence, PS will attract each other while PQ and PR will repel each other, since PR are further apart, the repelling force will be weaker than the force between PS and PQ,
24.	**A**	There is maximum cutting of the magnetic field when the coil is horizontal therefore the induced e.m.f. will be the greatest. OR Since $E = -\frac{dN\Phi}{dt}$, the graph of magnetic flux linkage and that of induced e.m.f. will be out of phase by π/2, thus when magnetic flux linkage is zero, induced e.m.f. will be maximum.

25.	**A**	According to Faraday's law, $E = -\dfrac{dN\Phi}{dt}$. Magnitude of induced e.m.f. in coil = $= \dfrac{B\Delta A}{\Delta t} = \dfrac{5.00(\pi(8.0\times10^{-2})^2)}{10.0\times10^{-3}} = 10.1$ V Since resistance of coil is 4.00 Ω, current through coil = 10.1 / 4.00 = 2.51 A According to Lenz's law, direction of induced e.m.f. is to oppose the change causing it. Thus the direction of induced e.m.f. will produce a current to oppose the decreasing flux into the coil. Hence by right hand grip rule, the current will be flowing clockwise in order to produce flux going into the page.
26.	**A**	Using turn ratio, voltage across the secondary coil is $120 \times \frac{10}{500} = 2.4$ V So current in secondary coil is $\frac{2.4}{15} = 0.16$ A. For ideal transformer, $120 \times I_p = 0.16 \times 2.4$ so $I_p = 0.0032$ A
27.	**C**	Diffraction is a phenomenon exhibited by waves. Electron undergoing diffraction shows that it has wave property.
28.	**B**	Energy (= *eV*) transferred to the electron and proton is the same, since they have the same magnitude of charge, so since $E = \frac{p^2}{2m}$, their momentum is given by $p = \sqrt{2mE}$, so their associate wavelength is $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}}$. Hence $\lambda \propto \frac{1}{\sqrt{m}}$ or $\frac{\lambda_p}{\lambda_e} = \sqrt{\frac{m_e}{m_p}} = \sqrt{\frac{9.11\times10^{-31}}{1.67\times10^{-27}}} = 0.0234$
29.	**C**	Original count rate per minute due to source = 532 – 24 = 508 per minute After two half-lives, the count rate would have dropped to 0.5*0.5*508 = 127. Taking the background count rate into consideration, the reading will be 127 + 24 = 151.
30.	**D**	Since the radiation is able to pass through 1 mm of aluminium sheet, it cannot be alpha radiation which can get blocked by paper. From the topic of electromagnetism, we learnt that the radius of the circular motion of a charged particle in a magnetic field is directly proportional to the speed of the particle. $r = \dfrac{mv}{qB}$ From the figure, we can see that the radius on left side of sheet is smaller than that on right side, thus it is likely that the radiation slowed down upon passing through the sheet. Therefore the path must be from Y to X.