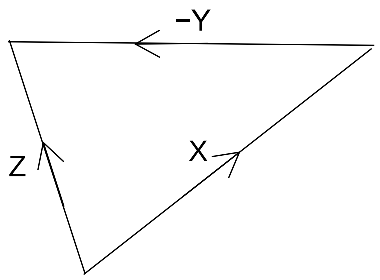
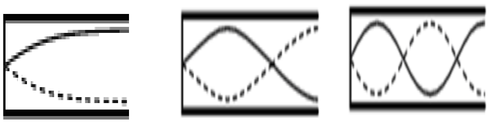
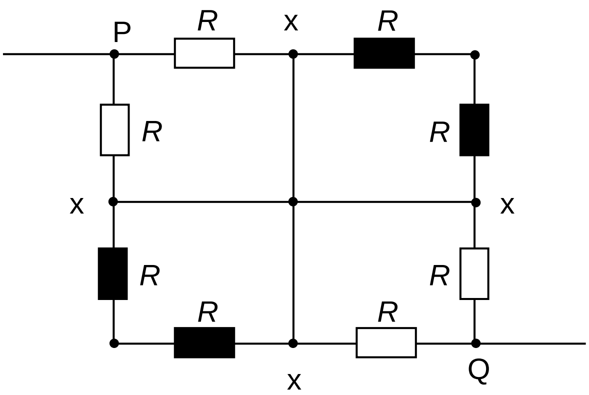
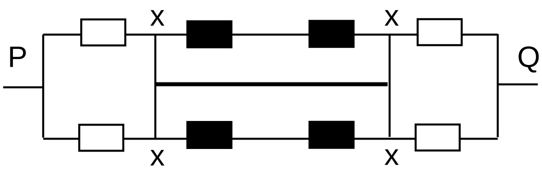
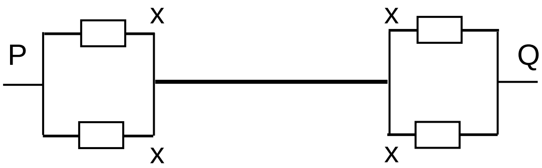
Anderson Serangoon Junior College 2024
JC2 H2 Physics Preliminary Examination Mark Scheme

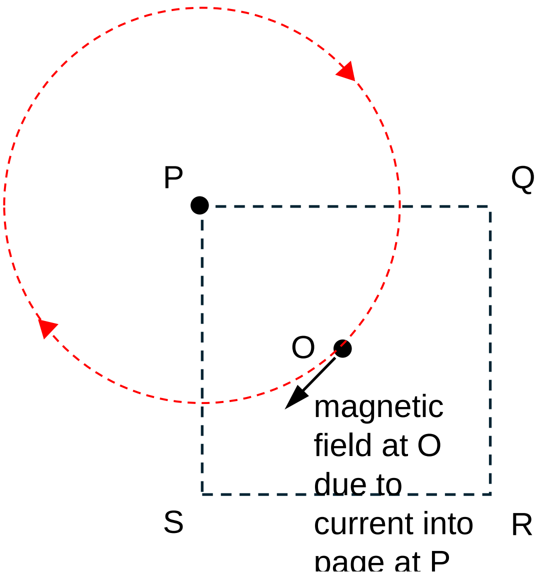
Paper 1 (30 marks)

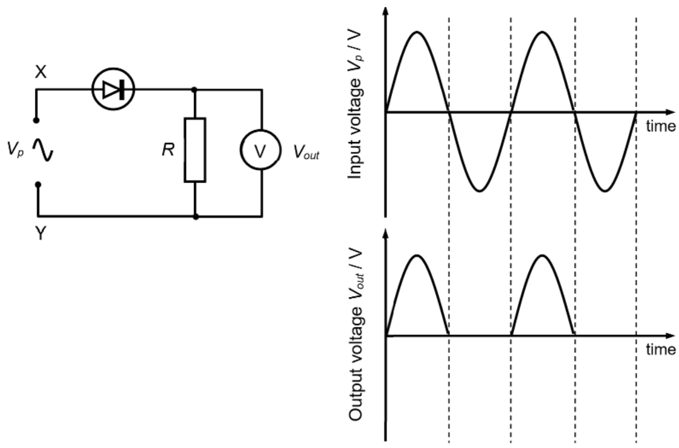
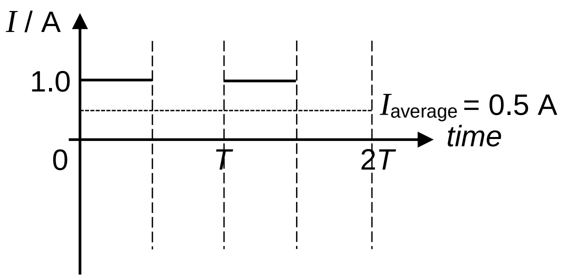
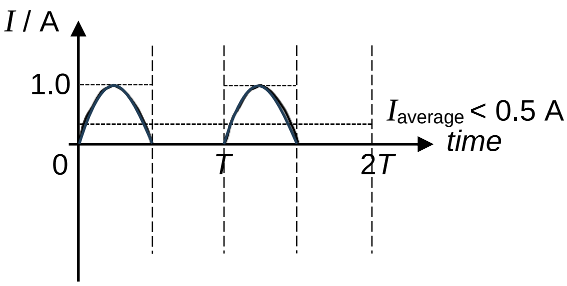
1	**D** intensity $I = \dfrac{E}{At}$ units of $I = \dfrac{kg\ ms^{-2}\ m}{m^2\ s}$ $= kg\ s^{-3}$
2	**A** Z = X + (–Y) as shown by the vector triangle below.  This is equivalent to option A.
3	**C** Constant speed up to t_1 means s increases at a constant rate, hence a straight line with positive gradient. As speed decreases at constant rate, distance travelled increases at a decreasing rate (decreasing gradient) and reaches a constant (zero gradient) when speed is zero.
4	**D** The vertical component of acceleration is the acceleration of free fall which is a constant in the absence of air resistance.
5	**C** Action-reaction must be of the same type. Weight is the gravitational force on the man due to the Earth.
6	**D** Consider vertical equilibrium of the object in water, taking upwards as positive $P + V\rho_{water}\, g - W = 0$ $\rho_{water} = \dfrac{W - P}{Vg}$

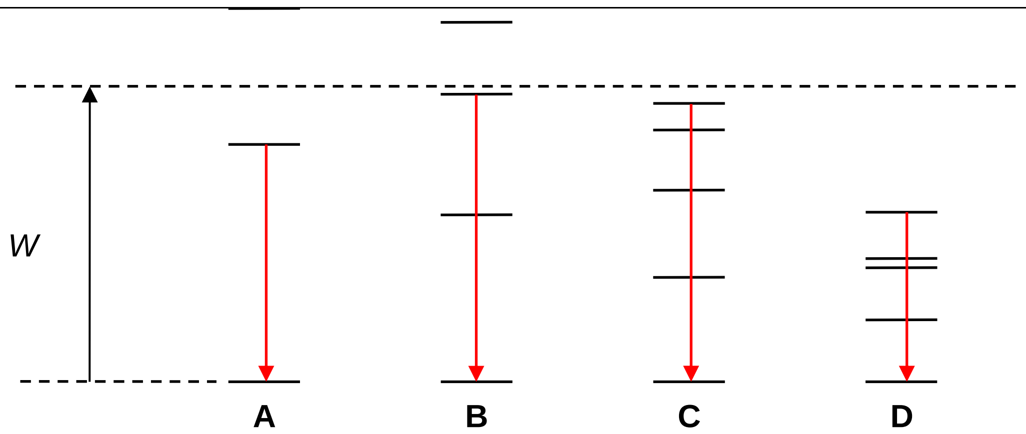
	Consider vertical equilibrium of the object in oil, taking upwards as positive $Q + V\rho_{oil}\, g - W = 0$ $\rho_{oil} = \dfrac{W - Q}{Vg}$ $\dfrac{\rho_{oil}}{\rho_{water}} = \dfrac{W - Q}{W - P}$
7	**A** By Conservation of Energy, loss in KE = Gain in GPE. ➔ $\Delta E = \Delta mgh = mg\Delta h$ Hence E varies linearly with height, i.e. a straight line. Since y is vertical displacement, at maximum height (largest y value) E = 0. Hence the answer is A.
8	**B** Total work done by man = Work done against friction + gain in GPE (since KE is constant) Work done against friction = 1500 – mgh = 1500 – 5.0 x 9.81 x 12 = 911. 4 J Average friction = work done against friction / distance travelled along plane = 911.4 / ($\dfrac{12}{\sin 30^\circ}$) = 37.9 ≈ 38 N
9	**B** Period = $2\pi / (\pi/2)$ = 4 s. After 6s, the marble would have completed 1.5 cycles, so directly opposite P, so displacement = 2r = 2 x 0.80 m = 1.6 m.
10	**C** Let *m* be the mass of the satellite and *M* be the mass of Earth. GPE of orbiting satellite = $-\dfrac{GMm}{r}$ and KE = $\dfrac{GMm}{2r}$ When satellite moves closer to the surface of Earth, *r* decrease. From the equations, GPE becomes more negative, so GPE decreases. KE increases, hence orbital speed increases.
11	**B** According to definition for thermodynamic temperature scale.
12	**D** As the temperature has stabilised, the rate of increase of internal energy (ΔU) = 0.

	The filament is hotter than its surroundings, loses heat (Q). Thus, rate of heating the filament is negative. Positive work (W) is done on the filament by electric current (recall the potential difference across a component in a circuit as the work done to drive a unit charge through the component).
13	**A** Option A implies a <u>once off</u> energy transfer to the rear-view mirror when the car goes over a speed bump (i.e. no external <u>periodic</u> driving force). The rest of the options allow for resonance to occur when the driving frequency matches the natural frequency of the oscillating system.
14	**C** Option C follows the definition of amplitude of oscillation.
15	**C** Using $x = \lambda D/a$, $\lambda = (0.008)(0.0001) / (2.0) = 4.0 \times 10^{-7}$ m Since the two sources are in phase at the slits and destructive interference occurs at the screen when their path difference = (n + ½) λ At 2nd order dark fringe, n = 1 Thus, path difference = $(1 + ½)\,\lambda = 1.5\,(4.0 \times 10^{-7}) = 6.0 \times 10^{-7}$ m
16	**C** Only the odd number harmonics can be formed in the bugle. Hence, the different frequencies follow the expression $(2n+1)f$. 
17	**A** For wire X, $n = \dfrac{I}{vAq} = \dfrac{3.0}{(2.8\times10^{-2})\times\pi(5.0\times10^{-5})^2\times(1.6\times10^{-19})} = 8.526\times10^{28}\ \text{m}^{-3}$ n remains the same since wire X and Y are made from the same material. For wire Y, $v = \dfrac{I}{nAq} = \dfrac{2.0}{(8.526\times10^{28})\times\pi(1.0\times10^{-4})^2\times(1.6\times10^{-19})} = 4.7\times10^{-3}\ \text{m s}^{-1}$

18	**A** Resistance, $R=\dfrac{\rho l}{A}$ and potential drop across each wire $V=IR=I\left(\dfrac{\rho l}{A}\right)=I\rho\left(\dfrac{l}{A}\right)$ Since current and resistivity are constants, the potential drop increases with distance from X (i.e. length of wire in this case), and the smaller the cross-sectional area A, the larger is the drop per unit length of wire. So the last segment has the largest potential drop per unit length.
19	**C**  The above circuit can be redrawn as:  No current passes through the resistors in black as all current will pass through the bold wire (zero resistance).  This simplifies the circuit to a series connection of two sets of parallel resistors. So resistance across PQ = $R/2 + R/2 = R$
20	**A** Since the thermistor's resistance decreases as its temperature increases, in accordance with the potential divider principle, the potential difference (p.d.) across it decreases with increasing temperature. The thermistor and the fixed resistor are in series thus their potential differences add up to 10 V. Therefore the p.d. across the fixed resistor increases as the p.d. across the thermistor decreases due to increase in temperature. When the p.d. across the fixed resistance exceeds the built-in p.d. of the diode (0.3 – 0.7 V) the diode becomes forward biased and current starts to flow downwards through the lamp to light it up. Option C is wrong as the diode is always in reverse bias hence the lamp will not light up as current will not flow through the diode even if the p.d. in the fixed resistor exceeds the diode's built-in potential difference.

21	**D** The direction of electric field line at a point indicates the direction of electric force on a positive test charge placed at the point. Since an electron is a negative charge, it will experience an electric force in the direction opposite to that of the electric field.
22	**D** Since charges are of opposite signs and potential is a scalar, at the centre of the two point charges, the resultant potential is 0 (hence can be III or IV). Since charges are of opposite signs and electric field radiates outwards from positive charge and towards negative charges, the electric field along the line joining the two point charges acts along only a certain direction (hence can be I or II). Given that $E = -\frac{dV}{dr}$, the combination of III for electric potential and II for electric field strength is wrong and hence D is the correct answer.
23	**D** The magnetic field lines due to current in a conductor is made up of concentric circles centered about the conductor. The direction of the field can be found using the Right Hand Grip Rule. At O, the direction of the magnetic field is tangential to the circular field lines. For example, due to a current at P that is into the page, the direction of the magnetic field at O points towards S. Apply this to the options and D is the answer. 
24	**A** As the long straight wire moves towards the flat coil, the magnetic flux density in the area enclosed by the coil increases. Since $B = \frac{\mu_0 I}{2\pi d}$, for each speed, magnetic flux density inside the coil increases at an increasing rate. This results in the increasing rate of change of magnetic flux linkage leading to increasing induced e.m.f. in the coil. Thus, current increases.
25	**C** For a straight conductor moving perpendicularly in a uniform magnetic field, $E = Blv$. Since, B (magnetic flux density) and l (length of conductor) are constant, $E \propto v$.

	From *s-t* graph, the *v-t* graph is similar to the graph in C. Hence, answer is C.
26	**A** The input and output voltage due to single diode rectification is as shown below.  Since the peak voltage is 100 V and R = 100 Ω, the peak current is 1.0 A. Consider a current which varies with time in the following manner with respect to time. The average current would be 0.5 A as the 1.0 A current is averaged out equally over one period.  For a single diode rectified sinusoidal current, the mean will be less than 0.5 A as for most of the time the instantaneous current is less than 1.0 A as shown below. 
27	**B** To achieve shortest wavelength, this implies that the photon emitted has the highest frequency. Since energy of a photon is *hf* and is equal to the energy difference between two levels, the highest possible transition possible for each atom is shown in the diagram below. Hence atom B will give the greatest energy difference.

	
28	**C** $q\Delta V$ = gain in KE $q\Delta V = p^2/2m - 0$ $\Rightarrow$ $p = \sqrt{(2mq\Delta V)}$ Using de Broglie's equation, $\lambda = h/p = h/\sqrt{(2qm\Delta V)}$ Since *m* and *q* are the same for both cases, $\lambda \propto 1/\sqrt{V}$. $\lambda_0/\lambda_1 = \sqrt{(100/1)} = 10$
29	**D** Total mass of reactant is less than total mass of products, so energy has to be supplied for the reaction to take place. Energy supplied = $(1.0086 + 1.0097 - 2.0150)$ u c^2 / (1.6×10^{-19}) = 3 MeV
30	**B** The proton number decreases by 2 during alpha decay, and increases by 1 during beta decay.