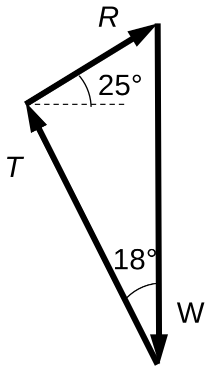
Anderson Serangoon Junior College 2020 H1 Physics Prelim Solutions

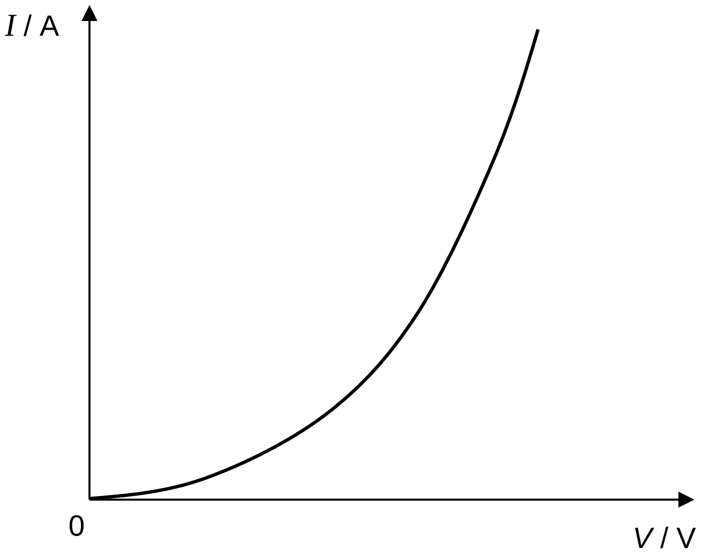
Paper 2 (80 marks)

1ai	**EITHER** By conservation of energy, Loss in k.e. = Gain in g.p.e. $\frac{1}{2} m (2.0^2 - v^2) = mg\Delta h$ $\frac{1}{2} (2.0^2 - v^2) = 9.81\ (0.13)$ $v = 1.204 = 1.2$ m s^{-1} **OR** Taking direction up the slope as positive, acceleration along slope, $a_{slope} = -$ g sin 30° Using $v^2 = u^2 + 2as$, we have $v^2 = 2.0^2 + 2(-$ g sin 30°)(0.13/sin 30°) $v = 1.204 = 1.2$ m s^{-1}
1aii	At the top of the ramp, horizontal component of velocity = v cos 30° = 1.2 cos 30° vertical component of velocity = v sin 30° = 1.2 sin 30° Using $s_y = u_y t + \frac{1}{2} a_y t^2$, and taking downward as positive, $0.13 = (-1.2 \sin 30°)t + \frac{1}{2} (9.81)t^2$ $t = 0.2351$ s $d = (1.2 \cos 30°)(0.2351)$ $= 0.2443 = 0.24$ m
1bi	Considering momentum in the direction at right−angles to the direction of the initial path of ball A: By Conservation of linear momentum, **EITHER** total initial momentum = total final momentum **OR** total initial momentum in the direction at right−angles to the direction of the initial path of ball A = 0 $0 = 4.0 \times 6.0 \sin \theta - 12 \times 3.5 \sin 30°$ $\theta = 61.04 = 61$ °
1bii	Considering momentum along the direction of the initial path of ball A: By Conservation of linear momentum, total initial momentum = total final momentum $4.0 \times v = 4.0 \times 6.0 \cos 61.04° + 12 \times 3.5 \cos 30°$ $v = 11.998 = 12$ m s^{-1}
1biii	total initial k.e. = ½ (4)(12)^2 = 288 J total final k.e. = ½ (4)(6.0)^2 + ½ (12)(3.5)^2 = 145.5 J Since the total kinetic energy before and after collision is different, the collision is inelastic.

2ai	 • arrows correctly labelled and form a closed loop • angles labelled correctly
2aii	**EITHER** use sine rule: $$\frac{T}{\sin(90° - 25°)} = \frac{W}{\sin[(90° - 18°)+25°]}$$ ➔ T = 474.8 = 470 N **OR** considering equilibrium of forces: $\sum F_Y = 0$ ➔ $R \sin 25° + T \cos 18° = W = 520$ $\sum F_X = 0$ ➔ $R \cos 25° = T \sin 18°$ Solving, T = 474.8 = 470 N
2bi	For the oil droplet to be equilibrium, it means that the electric force is upwards. Since this is a negatively charged droplet, the direction of electric field is downwards. Since electric field points from high to low potential, metal plate A is of a higher potential.
2bii	Since oil droplet is in equilibrium, weight = electric force $mg = qE$ $2.6 \times 10^{-14}(9.81) = (8 \times 1.60 \times 10^{-19})(E)$ $E = 1.99 \times 10^{5}$ N C^{-1}

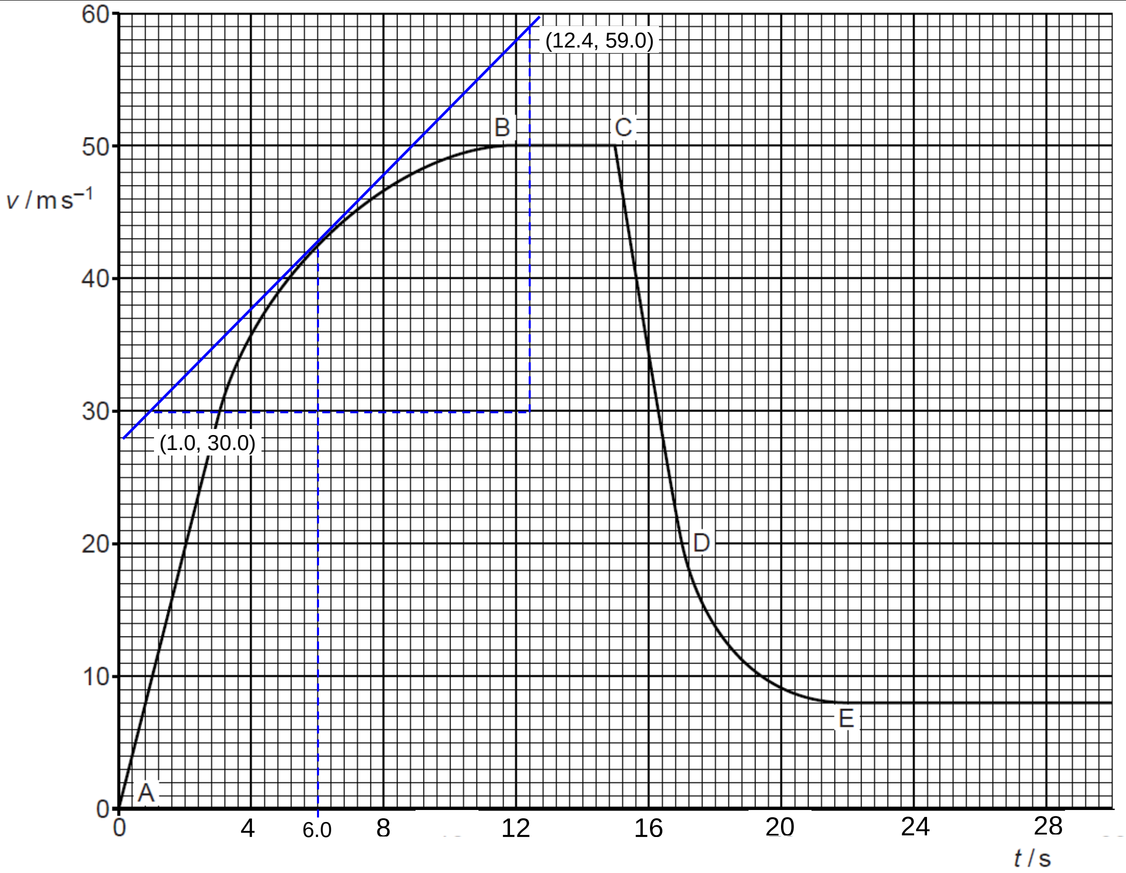
3a	elastic energy stored = ½ (1400)(0.10)^2 = 7.0 J
3bi	Using conservation of energy, Loss in EPE of spring = Gain in GPE of mass + WD against friction $7.0 = 2 \times 9.81 \times h_0 + 3.0 \times h_0$ Solving the equation, h_0 = 0.309 = 0.31 m
3bii	As the mass loses energy due to frictional forces on its way up and down, the elastic potential energy when the mass next comes to a stop will be lesser than at the start. Hence, the compression in the spring will be less than 10 cm.

4a	The direction of the velocity/momentum is always changing. Hence, there is a rate of change of velocity/momentum. Thus, by Newton's second law, there must have a resultant force acting on it.
4bi	Though all have the same angular speed, their linear speeds are proportional to their distances from the centre of the circle. No, they would not be at the same linear speed.
4bii	$\omega = (5.5 \times 2\pi)/60 = 0.57596 = 0.58$ rad s^{-1}
4biii	centripetal force required $= m r \omega^2$ $= 32 \times 3.25 \times 0.57596^2$ $= 34.500 = 35$ N The maximum friction is larger than the required centripetal force. Hence, he will not fall off.

5ai	 correct shape of graph showing resistance decreasing
5aii	As V increases, temperature increases, the number of charge carriers (positive holes and electrons) per unit volume increases, reducing resistivity. At the same times, the amplitude of vibration of atomic cores also increases, resulting in electrons making more frequent collisions with the atomic cores, increasing resistivity. The effect due to the increase in charge carriers per unit volume is more significant than the effect due to increased amplitude of vibration. Hence, resistance of thermistor decreases as V increases.
5bi	By potential divider rule, $V_{AB} = [R_{AB} / (R_{AB} + 1.2)] \times 9$ $0.444 = R_{AB} / R_{AB} + 1.2$ $R_{AB} = 0.96$ kΩ

5bii	For parallel combination, $1/960 = 1/1600 + 1/R_T$ R_T = 2.4 kΩ From the graph, temperature = 11°C (accept 10.75 to 11.25 °C)
5ci	Using scenario 2 (2nd row), it can be deduced that resistance of R_3 = 3.0 Ω Using scenario 3 (3rd row), resistance of R_2 + resistance of R_3 = 8.0 Ω Therefore, resistance of R_2 = 5.0 Ω Using scenario 1 (1st row), resistance of R_1 + resistance of R_2 + resistance of R_3 = 10 Ω Therefore, resistance of R_1 = 2.0 Ω
5cii	effective resistance between Z and B is $(1/2.0 + 1/5.0)^{-1}$ = 1.43 Ω effective resistance between Z and Y is 1.43 + 3.0 = 4.43 Ω Therefore, using potential divider rule, p.d. between W and Y = 3.0 /(4.43) × 12 = 8.13 V

6a	At t = 0 s, the only vertical force on the parachutist is his weight, hence his vertical acceleration is 9.81 m s^{-2}. Note: do not allow for calculation using gradient At t = 6.0 s, draw tangent and find gradient of tangent to graph. vertical acceleration = $\frac{59.0-30.0}{12.4-1.0}$ = 2.5 m s^{-2}

	
6b	no. of big squares = 11 total vertical distance = 11 × (10×4) = 440 m
6c	point C (vertical speed first starts to decrease)
6d	The (vertical) resultant force is given by weight – (vertical) air resistance As speed increases, (vertical) air resistance increases with speed and hence (vertical) resultant force decreases. The speed continues to increase until (vertical) resultant force equals to zero at point B (where (vertical) air resistance equals to weight). The parachutist moves at constant speed from B to C.
6ei	change in momentum, Δp $= m\,(v - u)$ $= 85\,(20 - 50)$ $= -2550 = -2600$ kg m s^{-1}
6eii	average vertical resultant force = $\Delta p/t = -2550 / 2$ $= -1275 = -1300$ N <u>Note:</u> allow for positive answer.
6eiii	Taking downward as positive, average vertical resultant force = weight – average vertical air resistance average vertical air resistance = weight – average vertical resultant force $= 85\,(9.81) - (-1275)$ $= 2108.85 = 2100$ N
6f	The parachutist comes to a complete stop over a longer period reducing the force of impact.

	The force of impact on the parachutist is also distributed across various parts of the body (instead of a single part), reducing the risk of injury.

7a	Newton's law of gravitation states that the mutual force of attraction between any two point masses is proportional to the product of the masses and inversely proportional to the square of their separation.
7b	gravitational force on the satellite provides centripetal force. By Newton's 2nd law, $$\frac{GMm_{\text{satellite}}}{r^2} = m_{\text{satellite}} r\omega^2$$ Since $\omega = \frac{2\pi}{T}$, the above equation becomes $$\frac{GM}{r^2} = r\left(\frac{2\pi}{T}\right)^2$$ Rearranging the equation, $$T^2 = \frac{4\pi^2 r^3}{GM}$$ $$= \frac{39.5\, r^3}{GM}$$
7ci	A geostationary orbit has an orbital plane that is the same as the Equator. The period of a geostationary orbit is 24 hours. The satellite in a geostationary orbit moves from west to east (in the same direction as the rotation of the Earth).
7cii	Substituting T = 24 × 60 × 60 into the equation in **(b)**, we have $$r^3 = \frac{GMT^2}{39.5} = \frac{6.67\times10^{-11} \times 5.97\times10^{24} \times (24\times60\times60)^2}{39.5}$$ $r = 4.2219\times10^7$ $= 4.22\times10^7$ m (3 s.f.)
7ciii	linear speed of the satellite at geostationary orbit = $r\omega = 4.2219\times10^7 \times \frac{2\pi}{24\times60\times60}$ $= 3070.25$ $= 3100$ m s^{-1}
7civ	By conservation of energy, loss in k.e. of satellite = gain in g.p.e. of satellite $\frac{1}{2}(655)(v_{min}^2 - 3070.25^2) = 3.45\times10^{10}$ $v_{min} = 10713$ $= 1.07\times10^4$ m s^{-1} (3 s.f.)
7cv	There is work done against air resistance as the satellite moves through the atmosphere that was not accounted for.
7di	disrupts the working of communication satellites/ damages components on satellites
7dii	magnetic force on charge particle provides centripetal force.

	By Newton's 2nd law, $$Bqv = \frac{mv^2}{r}$$ $$m = \frac{Bqr}{v} = \frac{6.05\times10^{-5} \times 1.60\times10^{-19} \times 50.0\times10^{3}}{2.90\times10^{8}}$$ $$= 1.6690\times10^{-27}$$ $$= 1.67\times10^{-27}\text{ kg}$$
7diii	proton/ hydrogen nucleus
7div