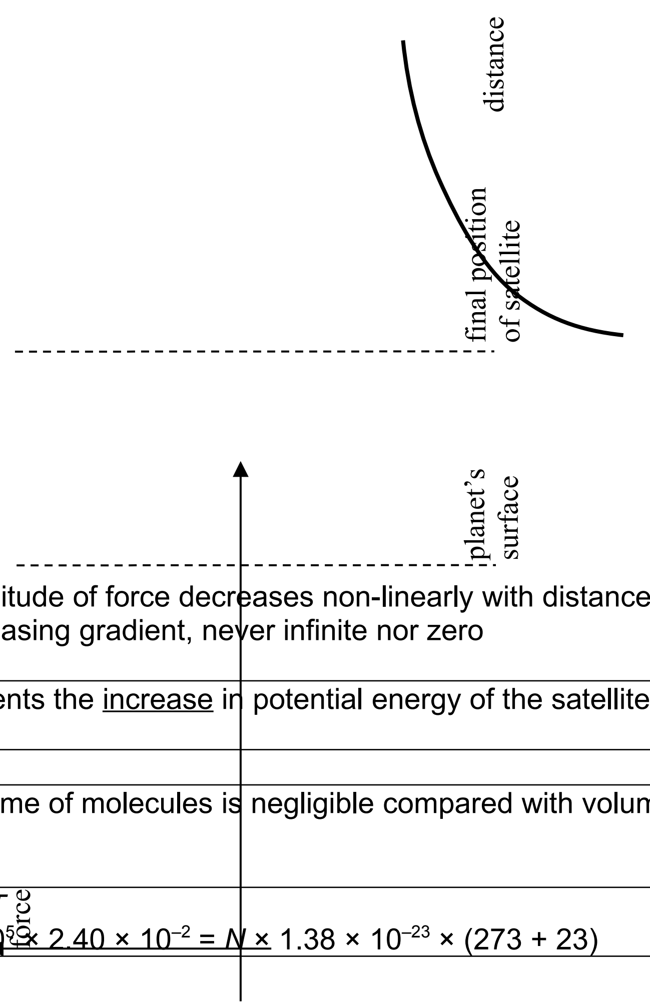
Anderson Serangoon Junior College 2021 H2 Physics Prelim Mark Scheme

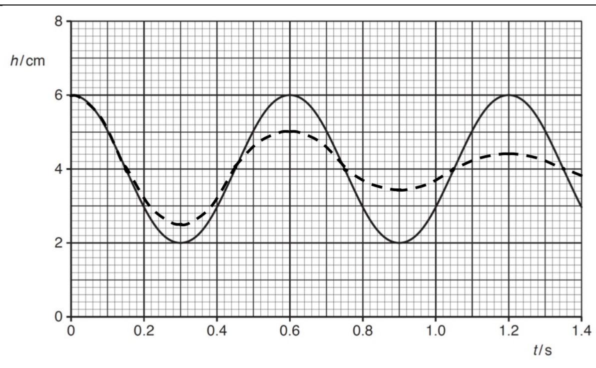
Paper 2 (80 marks)

1a	similarity: lines are radial / greater separation of lines with increased distance from the sphere / lines are perpendicular to the surface of sphere difference: gravitational field lines directed towards sphere and electric field lines directed away from sphere	B1 B1
1bi	The gravitational potential at a point is the work done per unit mass in bringing a small test mass from infinity to that point.	B1 B1
1bii	(gravitational) potential is taken to be zero at infinity (gravitational) force is attractive work done by the external agent on the point mass moving it from infinity is negative	B1 B1 B1
1ci	$\text{GPE} = -\dfrac{GMm}{r}$ $\text{increase in GPE} = -\dfrac{GMm}{(6.40+0.900)\times10^{6}} - \left(-\dfrac{GMm}{6.40\times10^{6}}\right)$ $=(6.67\times10^{-11})(6.00\times10^{24})(340)\left(\dfrac{1}{6.40\times10^{6}} - \dfrac{1}{(6.40+0.900)\times10^{6}}\right)$ $=2.62\times10^{9}\ \text{J}$	 M1 A1
1cii	 Penalise [1] if curve is drawn at distances less than planet's surface. No penalty if curve is drawn beyond final position. • magnitude of force decreases non-linearly with distance • decreasing gradient, never infinite nor zero	 B1 B1
1ciii	It represents the <u>increase</u> in potential energy of the satellite.	B1

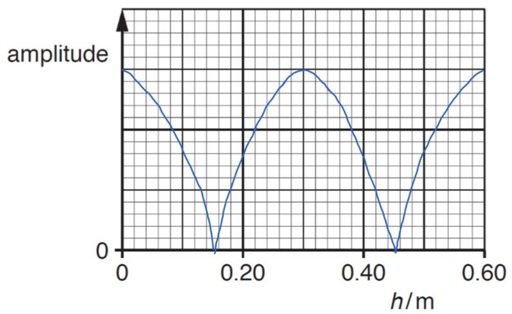
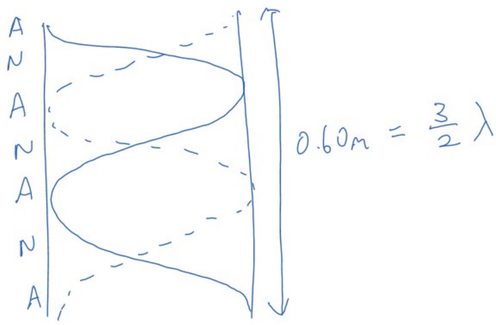
2a	total volume of molecules is negligible compared with volume occupied by the gas	B1
2b	$pV = NkT$ $4.60\times10^{5}\times2.40\times10^{-2} = N\times1.38\times10^{-23}\times(273+23)$	 C1

	$N = 2.7 \times 10^{24}$ volume of one molecule = $(4 / 3)\pi r^3$ (= 1.41×10^{-29} m^3) volume of all molecules = $2.7 \times 10^{24} \times 1.41 \times 10^{-29}$ = 4×10^{-5} m^3 (1 s.f.; as this is an estimation question the uncertainty of final answer cannot be more precise than that of the given data.) **or** volume of one molecule = d^3 (= 2.7×10^{-29} m^3) volume of all molecules = $2.7 \times 10^{-29} \times 2.7 \times 10^{24}$ = 7×10^{-5} m^3 (1 s.f.; as this is an estimation question the uncertainty of final answer cannot be more precise than that of the given data.)	 C1 A1

2c	Since volume of all atoms (4×10^{-5} m^3 or 7×10^{-5} m^3) is *3 orders of magnitude less* than volume occupied by the gas (2.4×10^{-2} m^3), so assumption in (a) is justified.	B1
2d	work done on gas (P → Q): 0 increase in internal energy (P → Q): (+)97.0 J increase in internal energy (Q → R): –42.5 J work done on gas (R→P) $W = p\,\Delta V = 2.10 \times 10^5 \times (1125 - 950) \times 10^{-6} = 36.8$ J increase in internal energy (R→P) since total change in internal energy is zero, $97 + (-42.5) + \Delta U = 0 \rightarrow \Delta U = -54.5$ J thermal energy supplied (R→P) $Q = \Delta U - W = -54.5 - 36.8 = -91.3$ J	 A1 A1 A1 A1 A1

3a	amplitude = 0.020 m $f = 1/T = 1/0.60 = 1.7$ Hz $a = (-)\omega^2 x$ **and** [$\omega = 2\pi f$ **or** $\omega = 2\pi/T$] $= (2\pi/0.60)^2 \times 2.0 \times 10^{-2}$ $= 2.2$ m s^{-2} [accept –ve a]	**E**	C1 C1 A1
3b	Resultant between upthrust and weight Upthrust increases with depth of immersion	**A**	B1 B1
3c	wave starting with a peak at (0,6), and same period peak height decreasing successively exponentially wrt time. 	**A**	B1 B1 B1
4a	*Polarisation* is where the oscillations in a wave are confined to one direction only in a	**E**	B1

	plane normal to the direction of transfer of energy of the wave. *OR* *Oscillations occur only in one plane, parallel to the direction of energy transfer.*		
4b	(A polarised wave vibrates in a single plane in space.) Since longitudinal waves vibrate along their axis of propagation, it is not possible to polarise a longitudinal wave. Hence, only transverse waves can be polarised as it vibrates perpendicular to its axis of propagation.	**A**	B1 B1
4c	Angle between axis of polarisation between images is 90°. Angle between axis of polarisation between left and right lenses is 90°. Angle of polarisation of each image needs to match angle of polarising axis of the lens for the appropriate eye.	**D**	B1 B1 B1
4d	(Since the plane of the images are perpendicular to each other), the two images are never added together in either eye.	**D**	B1

5ai	The incident wave reflects at the top of the tube. The incident and reflected wave interfere / superpose to form the stationary wave.	**A**	B1 B1
5aii	 Maximum value at h = 0, 0.30 m, 0.60 m, and 0 amplitude at h = 0.15 m, 0.45m. The line should be a modulus of a sinusoidal function.	**D**	 B1 B1
5aiii1	vertical/along length of tube/along axis of tube	**E**	B1
5aiii2	phase difference = 180°	**E**	B1
5aiv	When next stationary wave is formed: 0.60 m = 1.5 λ v = f λ, so f = v/λ = 340 / [0.60/1.5] = 850 Hz 	**A**	C1 A1
5bi	The waves spread as they pass through the slits.	**A**	B1

5bii	d sin θ = nλ sin θ = nλ/d	**D**	

	since $\sin\theta \le 1$, $n\lambda/d \le 1$ <u>when n=3 and $\lambda = 540 \times 10^{-9}$ m</u> $3(540 \times 10^{-9})/d \le 1$ $d \ge 1.62 \times 10^{-6}$ m <u>when n=3 and $\lambda = 630 \times 10^{-9}$ m</u> $3(630 \times 10^{-9})/d \le 1$ $d \ge 1.89 \times 10^{-6}$ m to satisfy both conditions above, minimum d is 1.89×10^{-6} m		C1 A1
5biii	<u>wavelength</u> of blue light is <u>shorter</u> (than both given lights) so the third order diffraction maximum is produced.	**A**	B1

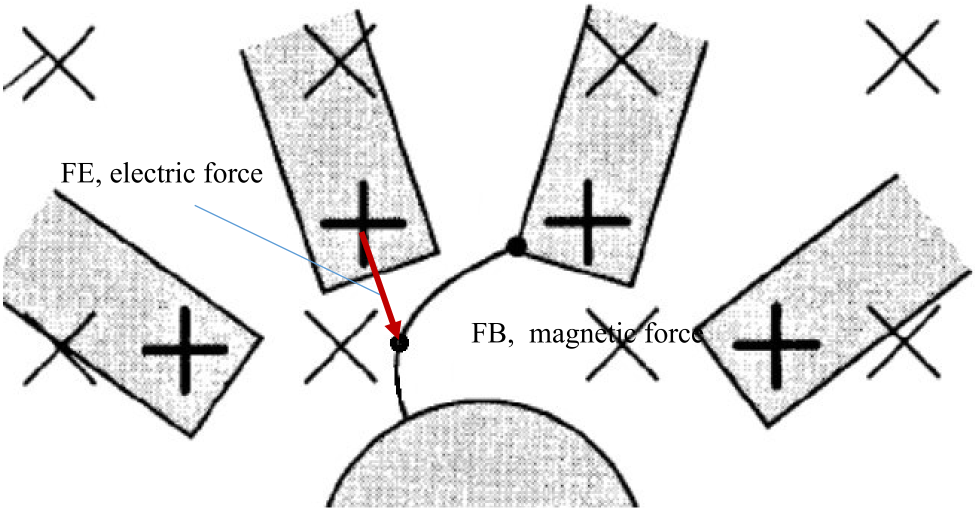
6ai	arrow from –0.85 eV level to –1.50 eV level	**E**	B1
6aii	$\Delta E = (1.50 - 0.85) \times 1.60 \times 10^{-19}$ $= 1.04 \times 10^{-19}$ J Since $\Delta E = hc/\lambda$ $\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8})/(1.04 \times 10^{-19})$ $= 1.91 \times 10^{-6}$ m	**A**	C1 A1
6b	Spectrum appears as dark background crossed by two bright lines. Electrons in gas de-excite, emitting photons with specific energies equal to the energy difference of two levels. These photons have specific frequencies (or wavelengths) which correspond to the lines.	**D**	B1 B1 B1

6ci	e.m. radiation produced whenever charged particle is accelerated electrons hitting target have distribution of accelerations	**A**	M1 A1
6cii	all electron energy given up in one collision/converted to a single photon (since $\lambda_{min} = hc/E_{max}$,) maximum photon energy corresponds to minimum wavelength	**A**	B1 B1

7ai *para 2*	To <u>prevent</u> <u>microwave/(em) radiation</u> from <u>leaking/escaping **out**/exiting</u> of the cage/microwave oven.	**E**	A1
7aii *para 1, 2 & 5*	From the passage, by international convention, microwave ovens operate at frequencies at around 2.45 GHz. Wavelength of the microwaves = <u>$3.00 \times 10^{8} / 2.45 \times 10^{9}$ Hz = 0.122 m</u> 100 times smaller than 0.122 m or 12.2 cm = 1.22×10^{-3} m or 0.00122 m. Hence, estimated spacing of holes is <u>1×10^{-3} m</u> or <u>1.2×10^{-3} m</u>.	**A**	 C1 A1

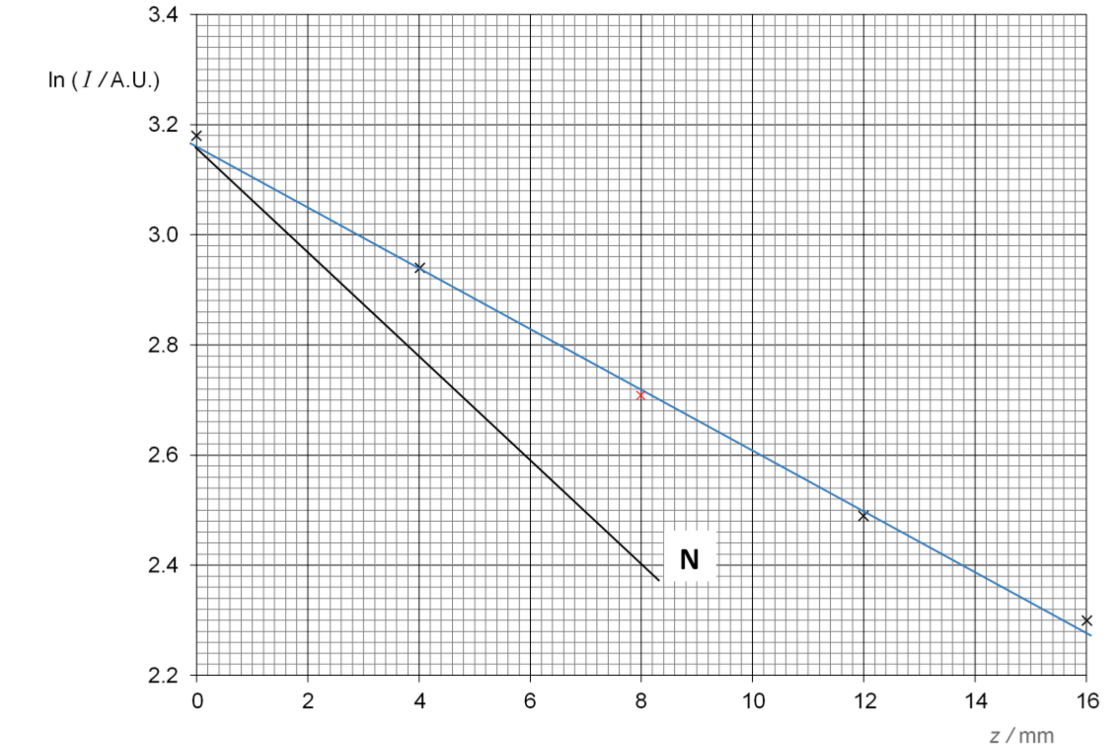
	[-1] Powers of Ten error for conversion of GHz		
7bi *para 3*	Potential difference across the electrodes = 5000.00 V By conservation of energy, <u>Kinetic energy gained by an electron = electrical potential energy loss by the electron</u> $= (5000.00)(1.60 \times 10^{-19}) = 8.00 \times 10^{-16}$ J $= 8.0 \times 10^{-16}$ J	**E**	 M1 A0
7bii *para 3*	Power output, P = (energy of an electron) $\times$ (n/t) Each electron has available max. 8.0×10^{-16} J of energy (assuming that the electrons start off from cathode with negligible kinetic energy) to be converted to microwaves. Least number of electrons per second $= \frac{1000}{8.0 \times 10^{-16}} = 1.25 \times 10^{18}\ s^{-1}$	**A**	 A1

7biii *para 3*	<u>Not all the (kinetic) energy of the electrons is converted into **microwave energy**</u> as: • electrons give off e.m. radiation of varying wavelengths as it accelerates towards the anode and hence actual energy possessed by electrons are lower when reaching the anode • some electrons hit the anode, some of its kinetic energy is also converted to thermal energy / passed to the molecules (or atoms) in the anode causing thermal agitation so less energy is available for conversion to microwave energy <u>Not all the microwaves generated from the energy is fed into the cavity resulting in energy losses</u> due to: • the walls in the cavity of the food chamber absorbing some of the microwaves • microwaves may be fed back / coupled back to the magnetron (resulting in actual useful power of microwaves less than the actual energy that can be supplied by the electrons) *Answer must be related back to the efficiency of **<u>conversion of energy of the electrons to the power output of the microwaves;</u>** **or** **<u>loss in microwaves produced fed into cavity</u>**.*	**D**	A1

7biv 1 *para 3*	 Correct direction of F_E drawn and labelled. (// to electric field line towards anode, see Fig. 7.3 for the electric field between the anode and cathode.) Correct direction of F_B drawn and labelled. (The velocity of the electron should be tangential to the trajectory. Apply Fleming's left hand rule to get direction, towards centre of "circular motion" and perpendicular to trajectory) *[-1] if F_E and F_B are not defined.* *Ignore weight if labelled. (Weight is insignificant to electric and magnetic forces)*	**A**	 A1 A1

7biv 2 *para 3*	As the magnetic force on the electron is acting perpendicular to its motion, (no work is done by the magnetic force on the electron), hence it does not affect the speed of motion as it moves towards the anode. Hence the maximum kinetic energy gained remains **unchanged**.	**D**	B1 A1
7ci *para 6*	see table below	**E**	A1 A1

depth into food z / mm	intensity of microwaves at depth z I / A.U.	ln (I / A.U.)
0	24	3.18
4	19	2.94
8	15	2.71
12	12	2.49
16	10	2.30

7cii **1.** **2.** *para 6*	 1. Plot the point accurately to ½ smallest square. 2. Appropriate best fit line drawn.	**E**	 A1 A1

7ciii *para 6*	Using (0, 3.16) and (15.2, 2.32), $\text{Gradient} = \frac{3.16 - 2.32}{0 - 15.2} = -\frac{0.84}{15.2} = -0.055$ *Correct computation of the gradient with two points on the best fit line.* *[-1] if the points are not read to ½ smallest square precision, ½ square off. If more than one square off [0] for whole part.* *[-1] if the two points chosen are less than half the line drawn* *No units are required. However, if units are incorrect [-1]*	**E**	C1 A1
7civ *para 6 & 7*	$I = I_o e^{-\mu z} \Rightarrow \ln I = \ln I_o - \mu z$ Hence, gradient of the graph = $-\mu$ When $z = \delta_p$, $I = I_o/e$ $\Rightarrow \frac{I_o}{e} = I_o e^{-\mu\delta_p}$ $\Rightarrow \delta_P = 1/\mu$ = 1/0.055 = 18 mm	**D**	C1 A1
7cv1 *para 5*	The potato mash with a higher water content would have <u>more of the microwave (energy)</u> **<u>absorbed at the surface/</u>** <u>more microwaves absorbed per unit length/per unit volume by the water molecules</u> as the microwaves move through the food, **(**the intensity of the microwaves will then fall to 1/e of its intensity at the surface in a shorter depth), causing the penetration depth to be <u>smaller</u>.	**D**	M1 A1
7cv2	**N** – straight line graph with y-intercept unchanged, gradient is steeper. *Graph must be coherent with conclusion of penetration depth obtained earlier.*	**E**	A1

para 6			