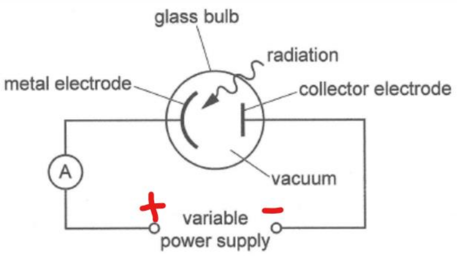
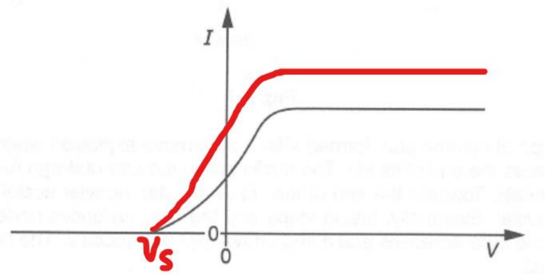
2023 A Levels H2 Physics 9749/02 Paper 2 suggested solutions

1a	When submerged, there is a higher pressure on the base of the block compared to the pressure on the top of the block. This difference in pressure produces a net upward force that causes an upthrust on the block.
1bi	Explain: Upthrust equals to the weight of fluid displaced. $upthrust,\ U = mg$ of fluid displaced $= \rho V g$ $= 1.0 \times 10^3 \times \frac{27.8}{(100)^3} \times 9.81$ $= 0.27272$ $= 0.27$ N *Note: Do not assume that stating the quantities meant explanation.
1bii	Taking moments about the pivot Sum of clockwise moments = sum of anticlockwise moments For Fig. 1.1 $F(18) = W(8.3) ------(1)$ For Fig. 1.2 $(F - U)(19) = W(7.8) ------(2)$ Solving equation (1) and (2) F = 2.49 N Note: For Fig. 1.2, there are two forces acting on the block, namely F (weight) and U (upthrust)
2a	At the highest point of the path, KE of the object is 65 J. $\frac{1}{2} m (v \cos(42°))^2 = 65$ $v = 20.69$ m s^{-1} vertical component of $v = 20.69 \sin(42°)$ $= 13.8 \approx 14$ m s^{-1}
2b	$v_y = u_y + at$ $0 = 14 - 9.81t$ $t = 1.43$ s Time taken for object to land $= 2t = 2.86$ s Horizontal displacement $= 20.69 \cos(42°) \times 2.86 = 44.0$ m
2c	Time taken to rise reach maximum height is shorter than the time it takes to return to the ground as the deceleration of the object rising upwards is larger than the acceleration of the object as it is falling.
3ai	$F = \frac{GMm}{r^2} = \frac{(6.63 \times 10^{-11})(6.0 \times 10^{24})(6800)}{((6400 + 36\,000) \times 10^3)^2}$ = 1500 N
3aii	$\frac{GMm}{r^2} = mr\left(\frac{2\pi}{T}\right)^2 \Rightarrow T^2 = \frac{4\pi^2}{GM} r^3$ period T is independent of m (mass of satellite) so all satellites in geostationary orbit need not have mass of 6800 kg, i.e. can be any mass.
3bi	$Bqv = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{Bq} = \frac{3.4 \times 10^{-23}}{1.8 \times 10^{-3} \times 1.60 \times 10^{-19}}$ = 0.12 m

3bii	radius r depends on the momentum of the ion, ions with different momentum would have different radius of path (there could be different isotopes of different mass and momentum) .
4ai	A stationary wave is formed when the sound wave from the loudspeaker is incident on the metal plate and reflects. The incident wave and reflected waves have the same wavelength and speed but are travelling in opposite directions. The incident and reflected waves overlap and are superposed, and the resulting wave is a stationary wave with points of maximum and minimum amplitude.
4aii	(showing construction lines on the graph) Distance between two successive troughs = 10.0 cm Time for two periods = 10.0 x 0.50 = 5.0 ms frequency = $\frac{1}{5.0\times10^{-3}\div2} = 400\,\text{Hz}$
4aiii	distance between adjacent nodes is half a wavelength. $\lambda = \frac{v}{f} = \frac{340}{400} = 0.85$ $\frac{\lambda}{2} = 0.425$ distance = 0.425 m
4bi	The path difference is 0.4m which is 2 wavelengths. Since the waves from X and Y are emitted in phase and the path difference is an integer number of wavelengths, the waves meet in phase at point P. Constructive interference occurs and the amplitude of the sound at P is a maximum, thus the intensity of sound at P is a maximum.
4bii	$I = \frac{P}{4\pi d^2}$ Thus $I \propto \frac{1}{d^2}$ $\frac{I_Y}{4.5\times10^{-6}} = \frac{1.4^2}{1.8^2}$ $I_Y = 2.72\times10^{-6}$ W m^{-2}
4biii	Since $I \propto A^2$ $\frac{A_X}{A_Y} = \frac{\sqrt{I_X}}{\sqrt{I_Y}} = \frac{\sqrt{4.5\times10^{-6}}}{\sqrt{2.72\times10^{-6}}} = 1.29$
5a	As p.d increases from zero, the <u>ratio</u> of current to p.d increase. Since $V = IR$ and $\frac{1}{R} = \frac{I}{V}$ so $R = \frac{V}{I}$ hence the value of resistance decreases. Note: The words "gradient" or "reciprocal gradient" should not appear in the answer.
5bi	Since the resistors are in series, current is the same for both resistors (necessary to include since qn ask to "explain" your working) $P = I^2R$ hence $P \alpha\ R$ $\frac{P_{220\Omega}}{P_{640\Omega}} = \frac{220}{640} = 0.34$
5bii	No change to the ratio since the resistors are still in series (with the internal resistance) and hence current is still the same for both and hence is cancelled in the ratio of powers.

5biii	For Fig. 5.2 (circuit in series), $R_{eff} = 220 + 640 = 860\ \Omega$ For Fig. 5.3 (circuit in parallel), $R_{eff} = \left(\frac{1}{220} + \frac{1}{640}\right)^{-1} = 164\ \Omega$ Since $E = IR_{eff}$ and E is constant for both circuits, $I \alpha \frac{1}{R_{eff}}$ $\frac{I_{series}}{I_{parallel}} = \frac{164}{860} = 0.19$
5biv	Since the voltage of the power supply is still the same for both circuits and there is no change in the effective resistance of both circuits, there is no change in the ratio in biii.
6a	Faraday's Law of Electromagnetic Induction states that the induced e.m.f is directly proportional to the rate of change of magnetic flux linkage. Note: e.m.f. (electromotive force) is not electromagnetic force.
6b	When the wire oscillates periodically, it cuts the magnets' magnetic field lines which results in a rate of change of magnetic flux linkage. By Faraday's law, this induces an e.m.f. in the wire. By Lenz's law, if the wire forms a closed circuit, the induced current will flow in a direction to create an effect to oppose the change in flux linkage. In other words, the induced current will flow through the wire to produce a magnetic force to oppose the motion of the oscillating wire. Since the direction of the oscillating wire changes periodically, the polarity of the induced e.m.f. also changes periodically resulting in an alternating induced e.m.f. Note: It is important to recognise that e.m.f. is being induced as a result of magnetic flux being cut and the direction change of the e.m.f. as a result of the magnetic flux being cut in opposite directions.
6c	$\lvert\varepsilon\rvert = B\ell v$ = (250 x 10^{-3})(0.15)(0.80) = 0.030 V Note: Do not substitute the full length of the wire (0.35 m) as the full length of the wire is not in the magnetic field.
6d	Using Fleming's Left Hand Rule on the electrons in the moving wires, the electrons will experience magnetic force causing them to accumulate at both ends X and Y. Since the magnetic field, length and the velocity experienced are the same, the induced e.m.f. produced in both halves of the wire (X to the mid-length fold and Y to the mid-length fold) are the same in magnitude and polarity. Therefore, the net induced e.m.f. across the ends of X and Y of the wire is zero.
7ai	Photoelectric effect
7aii	Young's double slit experiment
7bi	 (the negative potential will repel electrons emitted so that ammeter reading decreases to zero)
7bii	$hf = \phi + eV_s$ $12.4\ \text{eV} = 4.2\ \text{eV} + eV_s$ $V_s = 8.2\ \text{V}$

7biii	Electromagnetic radiation exists as discrete bundles (quanta) of energy, known as photons, each photon has energy *hf*. In photoelectric effect, when EM radiation is incident on metal plate, each photon interacts with an electron on a one-to-one basis such that electron will be emitted from the surface of metal when the photon has sufficiently high frequency to overcome the work function of the metal. From the photoelectric equation, the stopping potential V_s is dependent on the work function Φ and the photon energy (*hf*) of the electromagnetic radiation. Increasing intensity merely increases the rate of incident photons on the metal surface. However, energy of each photon remains unchanged (since frequency of EM radiation is constant). The work function Φ of the metal remains unchanged (since metal is the same). Hence, the stopping potential V_s is independent of the intensity of EM radiation.
7ci &ii	
8a)	From the graph, time interval for 8 periods = 5.2 – 0.4 = 4.8 s angular velocity = $\frac{2\pi}{4.8 \div 8} = 10.5 \text{ rad s}^{-1}$
8b)	Since a neutron star is much denser than the original star, its radius *r* is much smaller. If the mass *m* remains about the same then the angular velocity ω must increase for angular momentum *L* to remain constant.
8c)	An iron-56 nuclide has the highest binding energy per nucleon of any nuclide. Thus, if an iron nuclide were to undergo fusion to form heavier nucleus, the binding energy per nucleon of the product would be lower. This means that total binding energy would decrease, and so net energy is required for fusion of iron. Hence this is not likely to spontaneously occur in the pulsar.
8di)	$g = \frac{GM}{r^2} = \frac{6.67 \times 10^{-11} \times 1.4 \times 2.0 \times 10^{30}}{10000}$ $= 1.87 \times 10^{12} \text{ N kg}^{-1}$
8dii)	$g_2 = \frac{GM}{r^2} = \frac{6.67 \times 10^{-11} \times 1.4 \times 2.0 \times 10^{30}}{10000^2} - \frac{6.67 \times 10^{-11} \times 1.4 \times 2.0 \times 10^{30}}{10001^2}$ $= 373 \times 10^{6} \text{ N kg}^{-1}$
8diii)	Since the gravitational field strength at the base of the rod is much higher than the top of the rod, the gravitational force at the base of the rod is very much higher than the top of the rod. There will be a very high tension in the rod and the rod will stretch so that its length increases. *note – the TYS answer that "the length remains constant" is incorrect. The phenomenon in this question is called "tidal forces of gravity causing spaghettification"

8ei)	velocity of a point on the surface of the pulsar with 2.0 ms period $v = r\omega$ $= 100000 \times \frac{2\pi}{2 \times 10^{-3}}$ $= 3.14 \times 10^{8}\ \text{m s}^{-1}$ Since the velocity at the surface of that pulsar would exceed the speed of light, which is impossible, the pulsar cannot have a period of 2.0 ms
8eii)	For a pulsar that does not disintegrate, the gravitational field strength at the surface must provide the centripetal acceleration required for circular motion of that point of the surface. $\frac{GM}{r^2} = r\omega^2$ Since the mass $M = \frac{4}{3}\pi r^3 \rho$ $G\left(\frac{4}{3}\pi r^3\right)\rho = r^3\omega^2$ $G\left(\frac{4}{3}\pi\right)\rho = \frac{4\pi^2}{T^2}$ $\rho = \frac{3\pi}{GT^2}$
8eiii)	$\rho = \frac{3\pi}{\left(6.67 \times 10^{-11}\right)\left(0.6\right)^2} = 3.92 \times 10^{11}\ \text{kg m}^{-3}$
8f	$age = \frac{33.5 \times 10^{-3}}{2 \times 38 \times 10^{-9}} = 440739\ \text{days} = 1200\ \text{years}$
8g	$\lambda = \frac{hc}{E} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{400 \times 10^{12} \times 1.6 \times 10^{-19}} = 3.1 \times 10^{-21}\ \text{m}$
8h	Either: A larger area for the SKA means that the power of the radio signals collected is higher, since power is intensity x area of collector. Thus the SKA is more sensitive and can detect pulsars with radio signal intensities that may be too weak for the Parkes Telescope to detect. Or: a larger square for the SKA area implies a larger diameter dish. From the Rayleigh Criterion, a larger diameter lens will have a higher resolution at the same radio frequency and therefore be able to distinguish pulsars which are very close to other astronomical objects which the Parkes Telescope cannot.