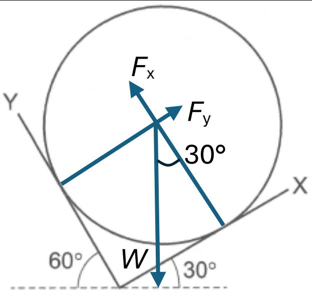
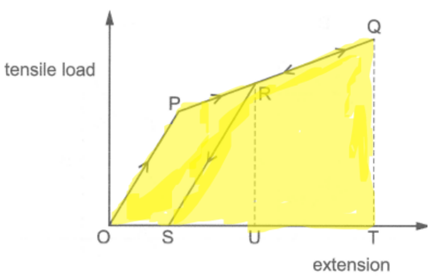
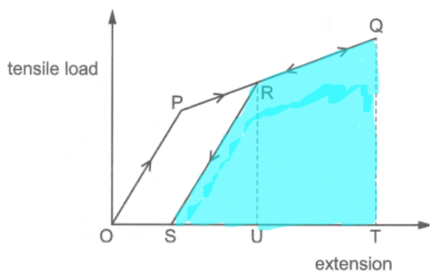
ANDERSON SERANGOON JUNIOR COLLEGE
PHYSICS 9478
Suggested Solutions to 2024 A Level P1

Topic	PYYQQ	Part	Suggested solutions
1	12401		**Ans: A** Area enclosed by the orbit $A = \pi r^2$ $= \pi \times \left(4\times10^2 \times 10^6\right)^2 = 5\times10^{17}$ m^2 = 5×10^{-1} Gm^2
2	12402		**Ans: B** Acceleration = gradient of v – t graph 0 – t_1: gradient is constant and positive 0 – t_2: gradient is constant and negative
2	12403		**Ans: C** Consider the vertical direction and taking downwards as positive: u_y = –15 sin40° m s^{-1}, v_y = 15 sin40° m s^{-1}, g = 1.62 m s^{-2} $v = u + at$ 15 sin40° = –15 sin40° + 1.62t t = 11.9 s
4	12404		**Ans: B** Equilibrium: Closed loop vector diagram 
4	12405		**Ans: D** Considering forces on the beam which is in equilibrium, so no net force vertically. Initial: upward forces by 3 springs = W, so 3kx = W Final: upward forces by 2 springs = 2W, so 2kx' = 2W = 2(3kx) x' = 3x
5	12406		**Ans: B**  Area 1 = WD on specimen to give extension T  Area 2 = Energy recovered when extension reduced back to 0 Net WD = area 1 – area 2

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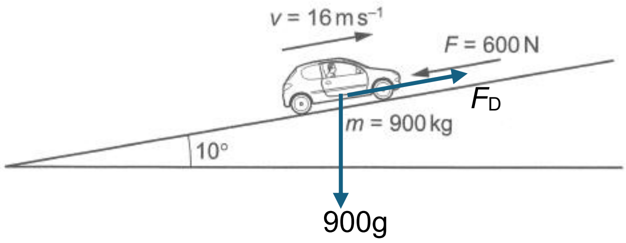
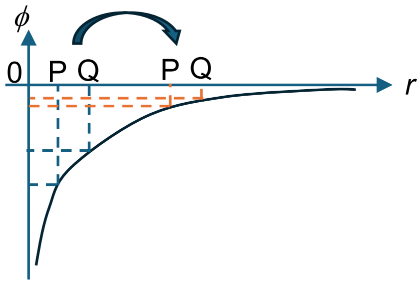
5	12407		**Ans: C** Driving force by car F_D $F_D - 600 - 900g\sin(10°) = 0$ $F_D = 2133$ N Power by engine = $F_D v$ = (2133)(16) = 34 kW 
9	12408		**Ans: D** Work done on gas are thermal processes where volume decreases
6	12409		**Ans: A** $s = r\Delta\theta$ ➔ $l = r(\Delta\theta)$ ➔ $\Delta\theta = \frac{l}{r}$ $\omega = \frac{\Delta\theta}{\Delta t} = \frac{l}{rt}$
6	12410		**Ans: A** $T = 24 \times 3600 = 86400\,\text{s}$ and $\omega = \frac{2\pi}{86400}$ rad s^{-1} $a = r\omega^2 = \left(\frac{1.3\times10^7}{2}\right)\left(\frac{2\pi}{86400}\right)^2 = 0.034$ m s^{-2} Since the object is undergoing circular motion, the acceleration is directed towards the centre of the circle, which is the centre of the Earth.
7	12411		**Ans: A** Potential $\phi = -\frac{Gm}{r}$ Magnitude of potential = $\frac{Gm}{r}$  Thus, as r increases, magnitudes of potentials decrease, and the magnitude of potential difference between them also decreases as magnitude of potential is a 1/r relationship.
8	12412		**Ans: A** Duration between collision of shaded side, $\Delta t = \frac{2x}{v}$ Change in momentum of particle, $\Delta p = 2mv$ Average Force by box on particle, $F = \frac{\Delta p}{\Delta t} = \frac{mv^2}{x}$ By N3L, magnitude of average force by particle on box = magnitude of force by box on particle.
9	12413		**Ans: D** Heat loss by V volume of water = heat gain by V/4 volume of water $(\rho V)c(60 - T) = \left(\rho\frac{V}{4}\right)c(T - 20)$ ➔ T = 52 °C

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10	12414		**Ans: C** At t = 0, mass at max displacement with zero speed. In one oscillation, mass crosses the equilibrium position twice, hence there are two peaks per period.
10	12415		**Ans: C** For critical damping, there is no oscillation, and the object returns to its equilibrium in the minimum amount of time.
11	12416		**Ans: C** $I_{Earth} = \frac{P_{sun}}{4\pi r^2}$ and $P_{received} = I_{Earth} \times Area\ of\ solar\ panel$ so $P_{received} = \frac{P_{sun}}{4\pi r^2} \times Area\ of\ solar\ panel$ $P_{received\ by\ Earth} = P_{received\ by\ Mars}$ $\frac{P_{sun}}{4\pi(1.5\times10^{11})^2}\times(1.0) = \frac{P_{sun}}{4\pi(2.3\times10^{11})^2}\times(Area\ of\ solar\ panel\ on\ Mars)$ Area of solar panel = 2.4 m^2
11	12417		**Ans: D** Resolving to vertical direction: $A_0\cos 15°$
12	12418		**Ans: D** Refer to definition of Rayleigh criterion
14	12419		**Ans: C** $I = nAvq$ Same current (I) and same material (so same n) Smaller diameter, smaller A, drift velocity is larger. (v
14	12420		**Ans: B** $R = \frac{\rho l}{A}$ Biggest area and shortest length to give minimum resistance
15	12421		**Ans: A** Using potential divider, Pd across 2.0Ω, $V_{2.0\Omega} = \frac{2.0}{2.0+1.0}(0.60) = 0.40\ \text{V}$ Same direction of polarity as the driver cell of 0.60 V.

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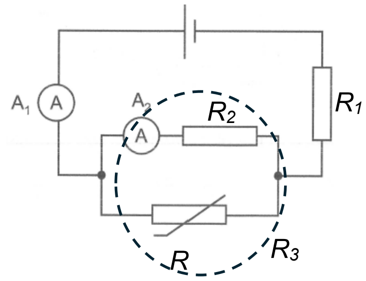
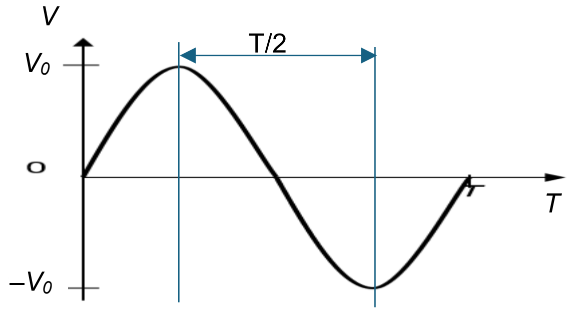
15	12422		**Ans: A**  T increases, R (thermistor) decreases R_3, the effective of R and R_2, will decrease Using potential divider between R_3 and R_1, p.d. across R_3 and hence p.d. across R_2 will decrease So A_2 will decrease. Overall resistance of circuit will decrease. So A_1 will increase.
16	12423		**Ans: C** Option A, Force by electric field on negative ion is out of the page Force by magnetic field on negative ion is into the page Both can cancel off for ion to go straight Option B, Force by electric field on negative ion is downward and forward Force by magnetic field is upwards. Vertical forces can balance and ion can accelerate forwards in a straight line Option C Force by electric field on negative ion is into the page Force by magnetic field on negative ion is downward Not possible Option D Force by electric field on negative ion is forward Force by magnetic field on negative ion is zero Ion can accelerate forward.
16	12424		**Ans: B** Magnetic force provides the centripetal force $F_B = Bqv = \frac{mv^2}{r} \rightarrow v = \frac{Bqr}{m}$ Period, $T = \frac{2\pi r}{v} = \frac{2\pi r}{Bqr/m} = \frac{2\pi m}{Bq}$
17	12425		**Ans: D** Area swept = 80 × (150 × 60) = 7.2 × 10^5 m^2 Flux cut = field density × area swept = $(1.0 \times 10^{-5})(7.2 \times 10^5)$ = 7.2 Wb
18	12426		**Ans: B** 

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18	12427		**Ans: A** Resistance of cables = (2 × 100)(0.030) = 6.0 Ω Current in cables = P/V = $(100 \times 10^6) / (400 \times 10^3)$ = 250 A Power loss in cable = $I^2R = (250)^2(6.0) = 3.75 \times 10^5$ W Power input to station = power output – power loss in cable = $100 \times 10^6 - 3.75 \times 10^5$ = 99.63 MW
19	12428		**Ans: D** $p = \frac{h}{\lambda}$ and $E = hc/\lambda = pc$
19	12429		**Ans: B**
20	12430		**Ans: D** Mass defect = total mass of nucleons + electrons – mass of atom = 26(1.00728+0.00055) u + (56-26) (1.00867 u) – 55.93493 u = 0.52875 u = 8.78×10^{-28} kg
2, 3, 5	22401	a	Increase in GPE = 27 J $mg\Delta h = 27$ $(0.43)(9.81)\Delta h = 27$ $\Delta h = 6.40 = 6.4\,\text{m}$
		b	At maximum height, $v_y = 0$ Using $v_y^2 = u_y^2 + 2as_y$ and take upwards as positive $0 = u_y^2 + 2(-9.81)(6.40)$ $u_y = 11.2 = 11\,\text{m s}^{-1}$
		c i	$\tan 32^\circ = \frac{u_y}{u_x} = \frac{11.2}{u_x}$ $u_x = 17.9 = 18\ \text{m s}^{-1}$ Apply conservation of momentum (0.43)(17.9) + (0.67)(0) = (0.43 + 0.67) v v = 6.997 = 7.0 m s^{-1}
		c ii	Vertical height is the same, so time of fall (or rise) is the same Horizontal speed is smaller for the combined object (by a ratio of 7.0/18 = 0.39), so the horizontal distance travelled is smaller by 0.39 of the horizontal distance travelled by the original object.
8, 9	22402	a	There are no inter-molecular forces between the molecules, except during a collision.
		b	Internal energy of an ideal gas is the total kinetic energy E_k of the molecules due to the random motion of the molecules. (No potential energy E_p due to intermolecular / inter-atomic forces between molecules.)

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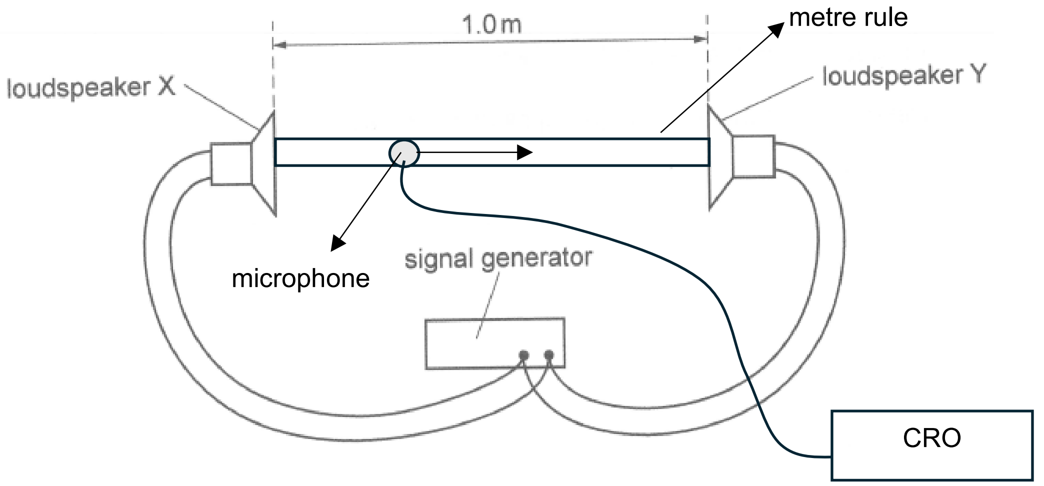
		c i	Total KE = $\frac{3}{2}NkT$ $= \frac{3}{2}(2.50\times10^{23})(1.38\times10^{-23})(21+273.15)$ $= 1522$ = 1520 J
		c ii	Increase in internal energy ΔU = ΔKE $= \frac{3}{2}(2.50\times10^{23})(1.38\times10^{-23})(15) = 77.6$ J Thermal energy is supplied to the gas and the gas will expand Work done by the gas = $P\Delta V$ = $(1.0\times10^{5})(6.3\times10^{-4})$ = 63 J Applying 1st law of thermodynamics $\Delta U = Q_{to} + W_{on}$ $77.6 = Q_{to} - 63$ ➔ $Q_{to} = 140.6 = 140$ J
12	22403	a i	So that waves from the loudspeakers have the same frequency / wavelength to ensure coherence.
		a ii	• Microphone connected to cathode ray oscilloscope (CRO) • Metre rule, clamped on retort stand, is placed between two speakers  Move the microphone directly along a horizontal line from centre of loudspeaker X to the centre of loudspeaker Y. Record the reading L_1 of the metre rule when first maximum intensity signal (antinode) is detected on the CRO. Record the number of antinodes N detected moving from X to Y. Record the reading L_2 of the metre rule for the last antinode detected near to Y. Wavelength is twice the average distance between two consecutive antinodes. So Wavelength = $\dfrac{L_2 - L_1}{\dfrac{N-1}{2}}$
		b i	$f = \frac{v}{\lambda} = \frac{340}{0.40} = 850$ Hz
		b ii	λ is 0.40 m, so distance between two consecutive nodes (or antinodes) is 0.20 m. Maximum amplitude = 0.18 + 0.18 = 0.36 mm The two waves started in phase, at mid point 0.50m, equal distance from both speakers, the waves meet in phase to give antinode.

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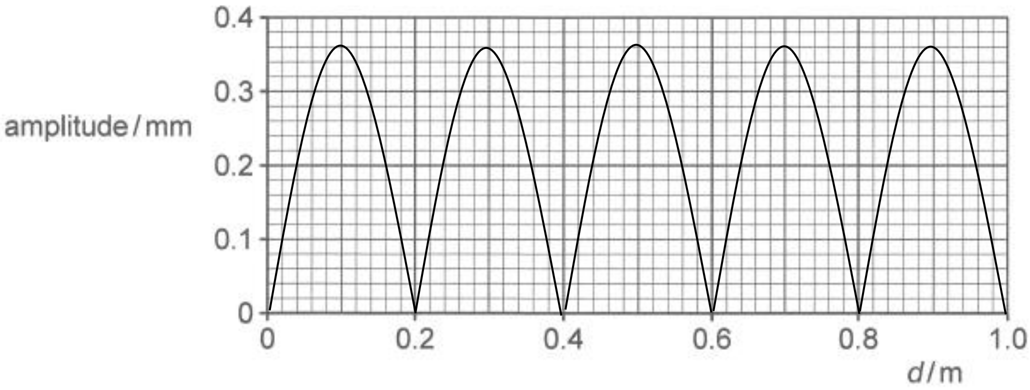
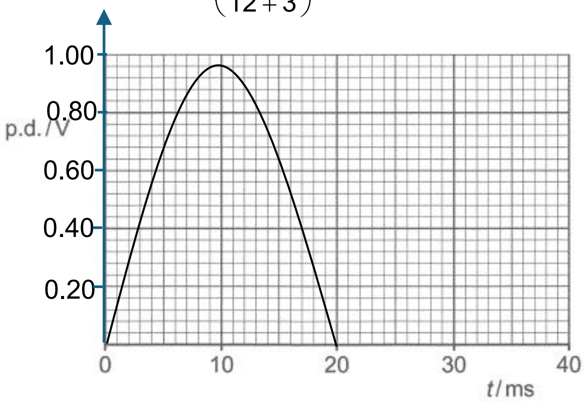
			
18	22404	a	Period T = 40 × 10^{-3} s $f = \frac{1}{T} = 25$ Hz $V = V_0 \sin(2\pi ft)$ $V = 4.8\sin(50\pi t) = 4.8\sin(157t)$
		b i	Total resistance = $12 + \left(\frac{1}{6} + \frac{1}{6}\right)^{-1} = 12 + 3 = 15\,\Omega$
		b ii	$V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{4.8}{\sqrt{2}} = 3.394 = 3.4\text{ V}$ $P_{mean} = \frac{V_{rms}^2}{R} = \frac{3.394^2}{15} = 0.7679 = 0.77$ W
		b iii	Resistance for two 6.0 Ω is 3.0 Ω and using potential divider principle, Peak voltage across P = $\left(\frac{3}{12+3}\right)4.8 = 0.96\text{ V}$ 
16	22405	a	$B = \frac{\mu_0 I}{2\pi d}$ $2.8\times10^{-4} = \frac{4\pi\times10^{-7} I}{2\pi\left(8.5\times10^{-3}\right)}$ ➔ I = 11.9 = 12 A
		b i	Magnetic field produced by lower current is normal to the current in upper rod, so $\frac{F}{L} = BI = \left(2.8\times10^{-4}\right)(9.2) = 0.002576 = 2.6\times10^{-3}$ N m^{-1}
		b ii	Weight per unit length of rod = (63/1000) × 9.81 = 0.618 N m^{-1} Total initial force per unit length exerted by two supports = 0.618 N m^{-1} Change in the force per unit length by two supports = magnetic force per unit length = 0.002576 N m^{-1} Percentage change by each support = $\frac{0.002576 \div 2}{0.618 \div 2} \times 100\% = 0.4168 = 0.42\ \%$

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		b iii	Using Right hand grip rule, direction of magnetic field acting on rod is directed out of the page. Using Fleming's Left Hand rule, the force on rod is directed upwards. **OR** The forces on two parallel wires that are carrying currents in opposite directions constitute a repulsion, so the change is a decrease.
		b iv 1	Using Right hand grip rule, direction of magnetic field acting on vertical rod is directed out of the page. Using Fleming's Left Hand rule, the force on rod is rightwards, perpendicular to the rod.
		b iv 2	Magnetic force per unit length decreases with increasing distance from wire. (Field strength exerted on the rod is inversely proportional to distance from the wire, so force per unit length is inversely proportional to distance from wire.)
20	22406	a	Most of the atom is empty space, the nucleus has a very small volume compared to the atom. So most α-particles do not come close to nucleus and hence travel straight. The nucleus is small, positively charged and massive compared to the α-particle. So only a small proportion of α-particles pass very close to the nucleus to experience large enough repulsive forces to cause them to deviate through angles greater than 90 °.
		b	Minimum separation when all KE is converted to EPE. Loss in KE = gain in EPE $\frac{1}{2}m_{\alpha}v^2 = \frac{Q_{gold}q_{\alpha}}{4\pi\varepsilon_0 r}$ $1.23\times10^{-12} = \frac{79e\times2e}{4\pi\varepsilon_0(r)}$ ➔ $r = 2.957\times10^{-14} = 2.96\times10^{-14}$ m
19	22407	a	Electrons at surface of the metal plate, just need to overcome the work function energy and leave the metal with maximum KE, max KE = energy of photon – work function energy. Photons may also interact with electrons not at the surface of metal. Electrons that are deeper in the metal, they collide with the lattice ions and other free electrons, thereby losing different amount of energy to come to the surface and hence emitted with KE less than the maximum value.
		b	$hf = \phi + KE_{max}$ $7.95 = \phi + 3.48$ ➔ $\phi = 4.47$ eV max λ of photon to give electrons emitted with zero KE $\frac{hc}{\lambda} = \phi + 0$ $\frac{(6.63\times10^{-34})(3.00\times10^{8})}{\lambda} = 4.47\times1.6\times10^{-19}$ ➔ $\lambda = 2.78\times10^{-7}$ m
		c	Higher intensity so number of photons per unit time hitting the metal increases More electrons emitted per unit time Time taken is reduced.
		d	The interaction of photon with electron is a one to one interaction. Energy of the photon at infrared wavelength is less than the work function energy of the metal. So electron does not have enough energy to overcome the work function energy and hence not emitted.
21, 20	22408	a	Lifespan is 14 yrs, half life is 87.7 yrs, so half life is long compared with lifespan. The activity at end of lifespan is $(1/2)^{14/87.7}$ = 90% of initial activity. Plutonium-238 can provide a stable power supply over the lifespan of Perseverance.

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		b	α-particles are massive compared with gamma or beta. More efficient in generating thermal energy (by collision).
		c	α-particles are least penetrative and most ionizing, hence caused most health hazards (e.g. radiation burns, mutation and cancer) only if absorbed by living organisms.
		d i	${}^{238}_{94}\text{Pu} \rightarrow {}^{234}_{92}\text{U} + {}^{4}_{2}\alpha$
		d ii	Energy = BE of U + BE of α – BE of Pu = $7.601 \times 234 + 7.074 \times 4 - 7.568 \times 238$ = 5.746 MeV = 9.1936×10^{-13} J = 9.194×10^{-13} J
		d iii	Number of moles = 4900/276 = 17.8 mol Number of nuclei = $17.8 \times 6.02 \times 10^{23} = 1.07 \times 10^{25} = 1.1 \times 10^{25}$
		d iv	Initial activity $A_0 = \lambda N_0$ $= \left(\frac{\ln 2}{87.7 \times 365 \times 24 \times 3600}\right)\left(1.07 \times 10^{25}\right)$ = 2.68×10^{15} Bq Power = $A_0\left(energy\right)$ $= 2.68 \times 10^{15}\left(9.194 \times 10^{-13}\right)$ = 2470 = 2500 W
		d v	Difference in mass number between plutonium and lead = 238 – 206 = 32 So number of alpha decays = 32 / 4 = 8 (note beta decays will not cause any change to mass number) Difference in proton number = 94 – 82 = 12 8 alpha decays will cause proton number to decrease by 16 So number of beta decay = 16 – 12 = 4 (note each beta decay will cause proton number to increase by one)
		e i	Exponential decrease means a reduction such that the rate of reduction of a quantity is proportional to the amount of the quantity at that time.
		e ii	Electrical output decreases exponentially by 0.79% per year, and initial electrical output is 110 W. So at end of lifespan of 14 years, output $= \left(1 - 0.0079\right)^{14} \times 110 = 98.4$ W
		f	emf $= \Delta S \Delta T$ = $[240 - (-200)] \times 10^{-6} \times (1273 - 573)$ = 0.308 V
		g	$g = \frac{GM}{r^2}$ Ratio of field strength of Mars to that of Earth $\frac{g_M}{g_E} = \frac{\frac{GM_M}{r_M^2}}{\frac{GM_E}{r_E^2}} = \frac{M_M}{M_E}\frac{r_E^2}{r_M^2}$ $\frac{g_M}{9.81} = \frac{1}{9.30} \times \left(1.88\right)^2$ $g_M = 3.728 = 3.73$ N kg^{-1}
		h i	Energy from RTG can first be stored in rechargeable batteries. This energy can then be used later to provide a greater power of 300 W to run MOXIE.

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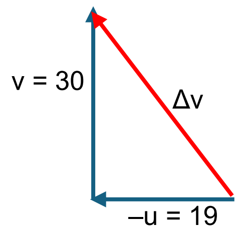
		h ii	$P_{moxie} = \frac{E_{moxie}}{t_{moxie}}$ ➔ $E_{moxie} = (300)(12400) = 3.72\times10^{6}$ J Energy from RTG = $3.72\times10^{6} = P_{RTG}t_{RTG}$ $3.72\times10^{6} = (110)t_{RTG}$ $t_{RTG} = 33818$ s = 9.39 hours
		h iii	Number of moles n = 5.37/32 = 0.1678 $PV = nRT$ $(610)(V) = (0.1678)(8.31)(-60+273.15)$ Volume = 0.487 m³
3,5	32401	a i	Increase in KE = $\frac{1}{2}mv^{2} - \frac{1}{2}mu^{2}$ = $\frac{1}{2}(0.060)(30)^{2} - \frac{1}{2}(0.060)(19)^{2}$ = 16.17 = 16 J
		a ii	$\Delta v = \sqrt{30^{2}+19^{2}} = 35.51$ m s⁻¹ $F = \frac{\Delta p}{\Delta t} = \frac{m\Delta v}{\Delta t}$ $= \frac{(0.060)(35.51)}{16\times10^{-3}}$ $= 133.1$ = 130 N 
		b	Some work done is converted to sound energy during impact Some work done is lost as heat. Not all energy in compressing the tennis ball / distorting the racket net is recovered when the tennis ball / racket net returned to original shape after hitting.
7	32402	a	Gravitational force on satellite provides the centripetal force for satellite in orbit $\frac{GMm}{(R+h)^{2}} = m\frac{v^{2}}{(R+h)}$ where v is the speed of the satellite $v^{2} = \frac{GM}{(R+h)}$ Kinetic energy $E_{k} = \frac{1}{2}mv^{2}$ $= \frac{1}{2}m\left(\frac{GM}{R+h}\right)$ $= \frac{GMm}{2(R+h)}$
		b	Gravitational potential energy of satellite GPE $= -\frac{GMm}{r+h}$ Total energy = Gravitational potential energy + kinetic energy $E_{T} = -\frac{GMm}{(R+h)} + \frac{GMm}{2(R+h)}$ $= -\frac{GMm}{2(R+h)}$

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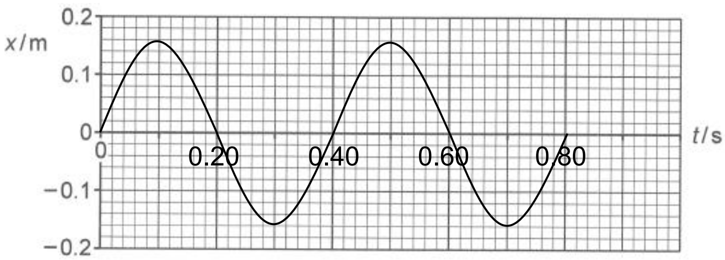
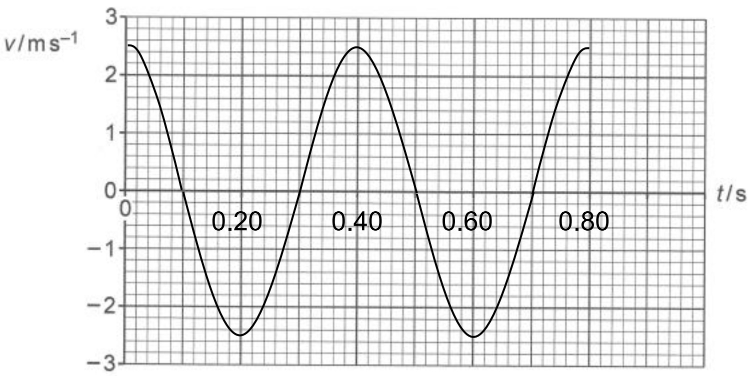
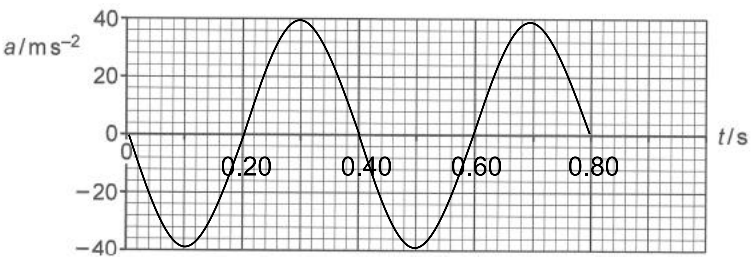
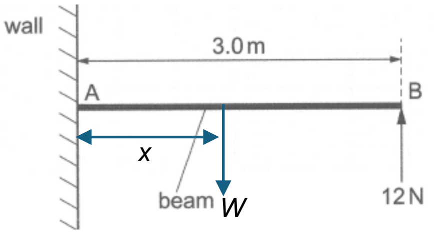
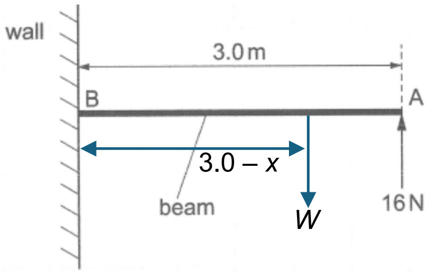
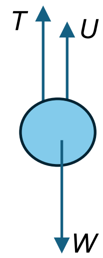
		c	$v^2 = \dfrac{GM}{(R+h)}$ $v^2 = \dfrac{(6.67\times10^{-11})(7.35\times10^{22})}{(1.74\times10^6 + 110\times10^3)}$ v = 1627.9 = 1630 m s^{-1}
		d i	h is now smaller, the gravitational attractive force is greater. F From $v^2 = \dfrac{GM}{(R+h)}$, the speed must also be greater for satellite to be in orbit. Given $E_K = \dfrac{GMm}{2(R+h)}$ so kinetic energy of P will be greater than that of S
		d ii	$E_T = -\dfrac{GMm}{2(R+h)}$, h is smaller, so E_T decreases. The decrease in gravitational potential energy is greater than the increase in kinetic energy. So total energy of P is less than that of S
10	32403		$\dfrac{2\pi}{T} = 15.7$ so period T = 0.400 s Also v_0 = 0.160 × 15.7 = 2.51 m s^{-1} a_0 = 0.160 × $(15.7)^2$ = 39.4 m s^{-2}   
4	32404	a	centre of gravity of an object is the point at which the whole weight of the body may be considered to act.

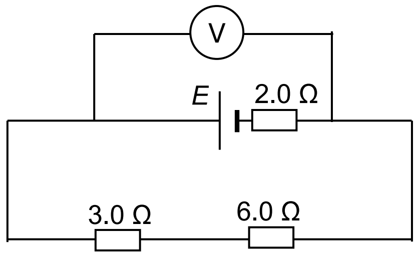
Topic	PYYQQ	Part	Suggested solutions
		b	Taking moment at A, $Wx = 12 \times 3.0 = 36$ ………….. (1)  Taking moment at B, $W(3.0 - x) = 16 \times 3.0$ $3W - Wx = 48$ ……………….. (2)  Solving eqn (1) & (2), W = 28 N and x = 1.2857 = 1.3 m
		c	The clockwise moment by weight at B is reduced by cos30°. The perpendicular distance from F to B is also reduced by the same amount. Hence the force is the same at 16 N.
4	32405	a	Density is mass per unit volume, Density of liquid, $\rho = \frac{m}{Ah}$, where m is the mass of the liquid. Hence weight of the liquid $W = mg = \rho Ahg$ Pressure is the force per unit area, Pressure at base of cylinder due to liquid, $p = \frac{F}{A} = \frac{W}{A} = \frac{\rho Ahg}{A} = \rho gh$
		b i	$A = \pi r^2 = \pi (3.0)^2 = 9\pi$ cm² $h = \frac{volume}{A} = \frac{370}{9\pi} = 13.086 \text{ cm} = 0.13 \text{ m}$
		b ii	$\text{pressure} = 880 \times 9.81 \times 0.13 = 1122 = 1100 \text{ Pa}$
		b iii	$U = \rho_{liquid} g V_{object} = (880)(9.81)(130 \times 10^{-6}) = 1.122 \text{ N}$  $T + U = W$ $T = 3.32 - 1.122 = 2.20 \text{ N}$
14, 15	32406	a	Similarity: Both are energy converted per unit charge, unit is volts. Difference: e.m.f. – energy converted from other forms of energy to electrical energy p.d. – energy converted from electrical to other forms of energy
		b i	The cell has internal resistance. With current flowing in the circuit, there is a potential drop across the internal resistance of the cell, hence p.d. across the terminal of the cell measured by voltmeter is less than e.m.f. of the cell.
		b ii	Effective resistance $= 3.0 + \left(\frac{1}{10} + \frac{1}{6.0 + 4.0} \right)^{-1}$ $= 8.0\ \Omega$ p.d. across the terminal of cell = p.d. across the effective resistance of the circuit. $V = IR_{effective} = (0.15)(8.0) = 1.2 \text{ V}$

<table>
<tr><th>Topic</th><th>PYYQQ</th><th>Part</th><th>Suggested solutions</th></tr>
<tr><td></td><td></td><td>c i</td><td>Effective resistance increases, hence the current in cell decreases.
Voltmeter reading V is also equal to $V = e.m.f. - Ir$
I is smaller but e.m.f. and r are constants, so V increases.

<table>
<tr><th></th><th>increases</th><th>decreases</th><th>remains the same</th></tr>
<tr><td>current in cell</td><td></td><td>✓</td><td></td></tr>
<tr><td>reading on voltmeter</td><td>✓</td><td></td><td></td></tr>
</table></td></tr>
<tr><td></td><td></td><td>c ii</td><td>Using $V = e.m.f. - Ir$
From b(ii), $1.2 = 1.5 - (0.15)r$ ➔ $r = 2.0\ \Omega$
Also effective resistance of the 3 resistors
(6.0 Ω, 9.0 Ω and 10 Ω) is $\left(\frac{1}{6.0+9.0} + \frac{1}{10}\right)^{-1} = 6.0\ \Omega$

The circuit in Fig. 6.2 can be simplified as shown

The p.d. across 10 Ω resistor
= p.d. across the effective 6.0 Ω resistor

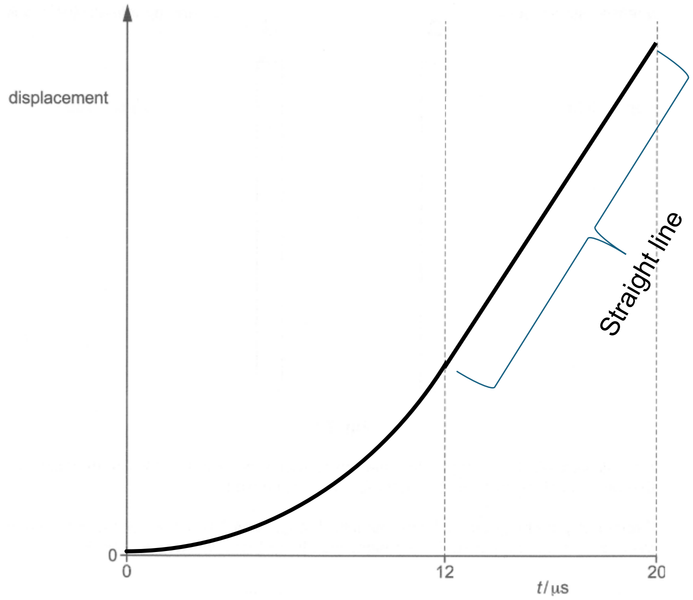
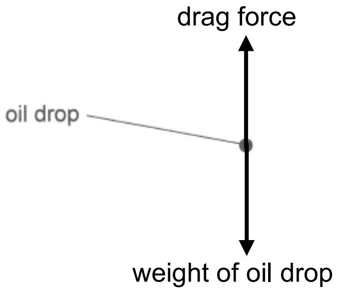
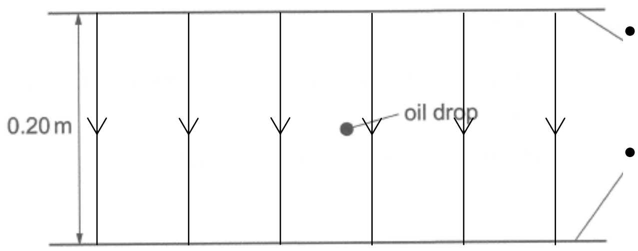
Using potential divider,
$V_{10\Omega} = \frac{6.0}{3.0+6.0+2.0}(1.5) = 0.8181 = 0.82\ \text{V}$

</td></tr>
<tr><td>17</td><td>32407</td><td>a</td><td>Faraday’s Law of Electromagnetic Induction states that the e.m.f. induced in a conductor is proportional to the rate of change of magnetic flux linkage (or rate of cutting of the flux).</td></tr>
<tr><td></td><td></td><td>b</td><td>Unmagnetized steel block falls and the loss in GPE is all converted to KE (assuming no air resistance).

The magnetized steel block falls through tube A, there is a change in flux linkage and cutting of flux by tube A.
E.m.f. and currents are induced in copper tube A.
Eddy currents dissipated as heating in the pipe.
Heating energy comes from the falling magnet.
Hence some of the loss in GPE is converted to heat energy, so the KE and speed are smaller than that of the falling unmagnetized steel block.

Or

As the magnetised steel bar moves through coil A, the magnetic flux through the coil changes.
By Faraday’s law of electromagnetic induction, this change in flux induces an emf in the coil.
According to Lenz’s law, the induced current flows in such a direction that the magnetic field it produces opposing the magnetic field of the moving steel bar.
This opposing magnetic field exerts a force on the bar opposite to its motion, reducing the net force on it.
As a result, the bar moves more slowly and takes a longer time to pass through tube A.

Unmagnetised steel block falls with acceleration of free fall (assuming no air resistance).</td></tr>
</table>

Topic	PYYQQ	Part	Suggested solutions
2, 13	32408	a i	
		a ii	 Constant velocity → no net force So same length for both arrows
		b i	 • Upper plate at higher potential. Direction of field from high to lower potential • Uniform field →equal spacing between lines
		b ii	From a(ii), $F_{drag} = W = (8.2\times10^{-16})(9.81) = 8.0442\times10^{-15}$ N Oil drop travelling at constant velocity of V0 upwards, so same F_{drag} but direction of air resistance is downwards. So electric force on oil drop, $F_e = W + F_{drag}$ $F_e = 2\times8.0442\times10^{-15} = 1.609\times10^{-14}$ N Electric field strength $E = \dfrac{\Delta V}{d} = \dfrac{5030}{0.20} = 25150$ V m^{-1} $F_e = qE$ ➔ $1.609\times10^{-14} = q(25150)$ $q = 6.40\times10^{-19}$ C
		b iii	Charge of an electron, e = 1.6×10^{-19} C $q = ne$ ➔ $6.40\times10^{-19} = n(1.6\times10^{-19})$ $n = 4$ 4 electrons are transferred to the oil drop.

Topic	PYYQQ	Part	Suggested solutions
		c i	$F_e = \dfrac{Qq}{4\pi\varepsilon_0 r^2} = \dfrac{\left(2.0\times10^{-6}\right)\left(1.1\times10^{-18}\right)}{4\pi\times8.85\times10^{-12}\times0.15^2} = 8.792\times10^{-13}$ N The net force is F_e. Weight (8.0×10^{-15} N) is ignored as the electric force is much greater than weight of oil drop. $F_e = ma$ $8.792\times10^{-13} = \left(8.2\times10^{-16}\right)a$ $a = 1070$ m s^{-2}
		c ii	The repulsive force between the oil drop and metal sphere is inversely proportional to square of separation. So the force is smaller as the separation between them gets bigger. Hence the oil drop is repelled away from the sphere and the acceleration of oil drop decreases with increase in separation. The velocity of oil drop increases at a decreasing rate. Hence, the displacement increases at an increasing rate.
12	32409	a i	The Principle of Superposition states that when two waves <u>meet</u> at a point, the resultant displacement is equal to the <u>vector</u> sum of the individual displacements.
		a ii	The light waves are waves of the same frequency with a constant phase difference
		b i	Path difference = 1.5 λ Note: 0.5 λ is the first minimum away from P.
		b ii	The two waves will meet antiphase at R. Amplitude of the resultant wave is the *difference* of the amplitudes of the individual waves, giving rise to a minimum resultant amplitude (i.e. destructive interference). Intensity is the square of the resultant amplitude, to give a minimum at R.
		b iii	$x = \dfrac{\lambda D}{a}$ ➔ $2.9\times10^{-3} = \dfrac{\lambda(2.70)}{0.60\times10^{-3}}$ $\lambda = 644$ nm $= 6.40\times10^{-7}$ m
		b iv	Double slit interference pattern comes from the superposition of two single slits diffraction patterns. Hence, intensities of double slit interference pattern are modulated by the single slit diffraction pattern. Central maximum is the brightest for single slit pattern, hence it is also a maximum for double slit pattern.
		c	Intensity I proportional to square of amplitude a $I = ka^2$ Amplitude from slit A, $a_A = \sqrt{\dfrac{I}{k}}$ Amplitude from slit B, $a_B = \sqrt{\dfrac{I}{2k}}$ Resultant amplitude at P, $a_P = \sqrt{\dfrac{I}{k}} + \sqrt{\dfrac{I}{2k}}$ Intensity at P $= k\left(\sqrt{\dfrac{I}{k}} + \sqrt{\dfrac{I}{2k}}\right)^2 = 2.91\,I$

Topic	PYYQQ	Part	Suggested solutions
		d i	1st order, the angle of diffraction θ is $\tan\theta = \dfrac{1.12}{2.70}$ ➔ $\theta = 22.529°$ $d\sin\theta = n\lambda$ ➔ $\left(1.67\times10^{-6}\right)\sin 22.529° = (1)\lambda$ $\lambda = 6.399\times10^{-7} = 6.40\times10^{-7}$ m
		d ii	1. Brighter and narrower bright fringes for diffraction grating 2. Distance from first maximum to P is larger for grating The position of 1st maximum for diffraction grating can be determined with less uncertainty and hence the wavelength as well.