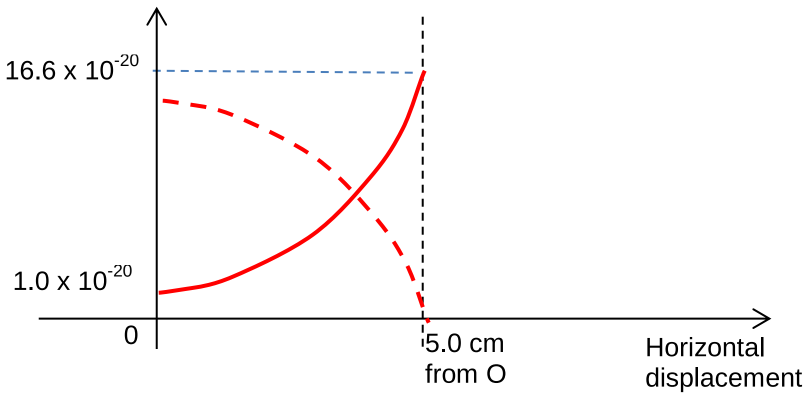
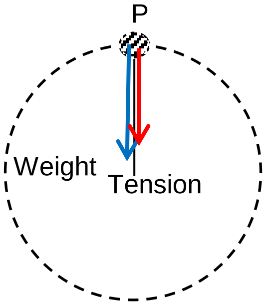
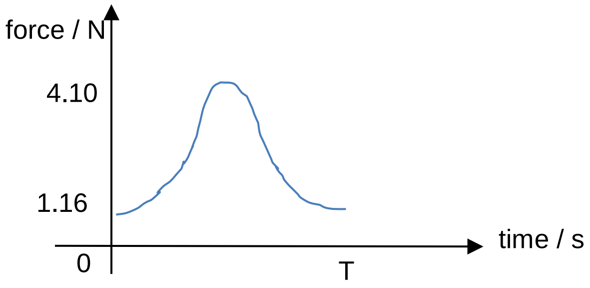
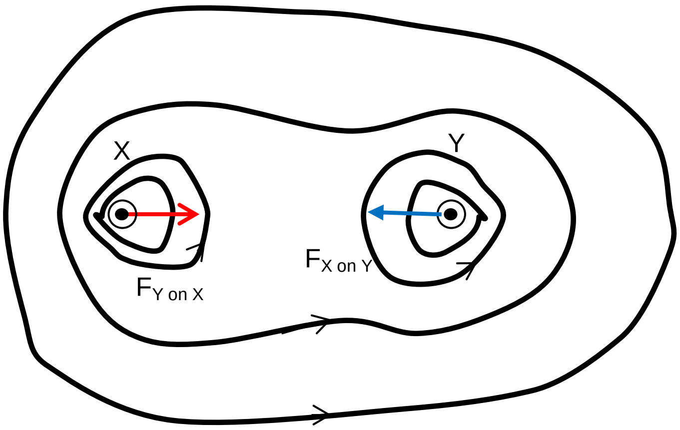
Qn	Suggested MS
1(a)	$x = v_x t$ ------ (1) find time to pass through parallel plate
	$a = \frac{Eq}{m}$ --------(2) find vertical acceleration by e-field
	$v_y = at$ ------(3) solve for v_y and substitution Solving (1), (2) and (3) gives $v_y = \left(\frac{Eq}{m}\right)\left(\frac{x}{v_x}\right)$
	$= \left(\frac{10 \times 1.6x10^{-19}}{9.1x10^{-31}}\right)\left(\frac{0.05}{1.5 \times 10^5}\right)$
	$= 5.8(54) \times 10^5\ m\,s^{-1}$
1(b)	$v = \sqrt{(5.854 \times 10^5)^2 + (1.5 \times 10^5)^2} = 6.0(43) \times 10^5 \mathrm{m\,s^{-1}}$
1(c)	
(i)	Quadratic graph as shown
	initial KE=1.0(25) x 10^{-20} J and KE at x = 5.0 cm is 16.6(1) x 10^{-20} J
(ii)	reflection of KE graph. (**ecf from (i)**) (KE + EPE must be seen to be approx. const)
2(a)	A radian is the **angle subtended by an arc** where the **arc length is equal to the radius**.
2(b(i)	Resultant force downwards provides centripetal force
	$F_R = \frac{mv^2}{r}$
	$F_R = \frac{0.15 \times 3.5^2}{0.7}$
	$F_R = 2.625 = 2.63\ N$
2(b) **(ii)**	T+W = 2.63 N T= 2.63 - W T =2.63 - 1.4715 = 1.1585 = 1.16 N

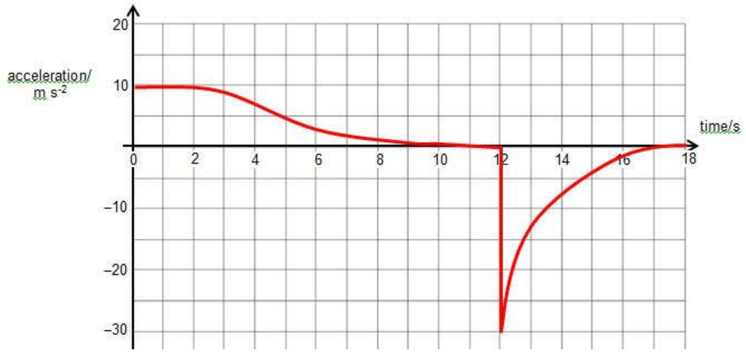
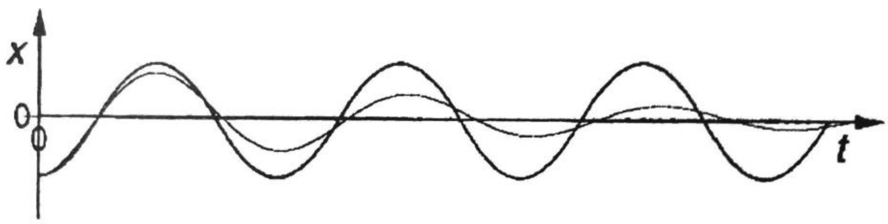
2(b)(iii)	
2(c)	At the bottom of its path Tension = 2.63N + W Tension =2.63N + 1.4715 = 4.096= 4.10 N Point M =4.10 N
	
	Shape as shown
	M labeled (value not reqd)
3(a)(i)	The potential difference V_{out} across R is $V_{out} = \frac{R}{R + R_T} V$
(ii)	V_{out} increases as R_T decreases
	As R_T decreases as the temperature increases.
	Hence V_{out} will increase to 8.0 V when the room temperature reached the temperature at which the fire alarm will be triggered to switch on. thus the circuit can be used to switch on the fire alarm when the pre-determined temperature is reached.
(iii)	$V_{out} = \frac{R}{R + R_T} V$; $12 = \frac{3}{3 + R_T}(8)$ $R_T = 1.5\ k\Omega$
	From the graph when $R_T = 1.5\ k\Omega$ The temperature is $83(\pm 1)^0C$
(b)	Is to set the value of the trigger voltage

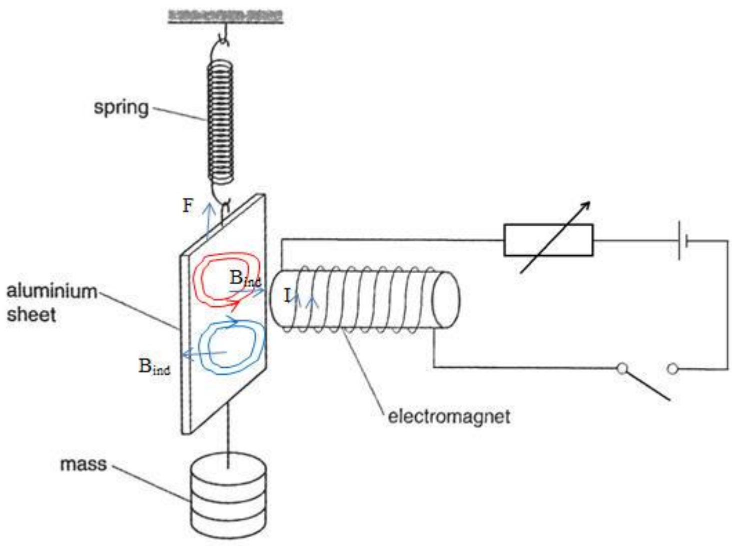
4(a)	
	Line density stronger next X; ignore shape
	Direction correct
	Shape as shown with neutral point nearer Y, no credit if drawn circular fields near conduct conductors
(b)	Correct direction of F on diagram (attractive forces) (*and equal length*)
(c)	The two forces are action and reaction pairs according to N3L, hence Magnitude of $F_{Y\ on\ X}$ = Magnitude of $F_{X\ on\ Y}$
4(d)	$F_X = BIl$ $\frac{F_X}{l} = (\frac{\mu_o I}{2\pi r})I$ $= \frac{\mu_o I_y}{2\pi d} I_x$ $= \frac{\mu_o I(2I)}{2\pi d}$ $= \frac{\mu_o I^2}{\pi d}$
	$\frac{F_Y}{l} = \frac{\mu_o I^2}{\pi d}$ (by N3L)
	Magnitude equal
	Value correct
5	
5(a)(i)	By applying the equation, ax =λD
	$(0.400 \times 10^{-3})(3 \times 10^{-3}) = \lambda \times (3.2)$
	$\lambda = 0.375 \times 10^{-6}$
(ii)	$\frac{path\ difference}{0.4x10^{-3}} = \frac{5x10^{-3}}{3.2}$
	Phase difference = $\frac{path\ difference}{\lambda} x 2\pi = 3.3\pi$

5(b)(i)	$\frac{additional\ path\ difference}{0.4x10^{-3}} = \frac{1x10^{-3}}{3.2}$
	(n-1) (1.0×10^{-6}) = 1.25×10^{-7}
	Hence, the refractive index of the gas is 1.125 (1.13)
6(a)	A: absorption spectrum; B: emission spectrum
(b)	Emission Line spectrum implies only light of certain frequencies are emitted.
	These frequencies corresponds to only specific energy differences.
(c)	Each element only absorb certain frequencies of light. The set of dark lines correspond to a particular element.
7(a)	**Change of velocity with time / Rate of change of velocity** (*and acts in the direction of change of velocity*)
(b)(i)	Knows that dist is area under graph
	Suitable method to find area
	Range accepted: 380 – 400 m
(ii)1	**Uniform acceleration**
	Only weight/gravitational force acting
(ii)2	**Acceleration decreasing** /speed increasing at decreasing rate
	Air resistance increases as speed increase hence **resultant force downwards decreases**
(ii)3	**Uniform speed**
	Air resistance = weight / **resultant force zero**
(iii)	Clear Workings shown with tangent drawn with Tangent drawn at 6.0 s
	Ans: 2.84 m s^{-2}
(iv)	(see table below)
	(g-a) at 6.0 s determined correctly
	Resultant force = mg – kv^2 = ma Hence if F_v **is proportional to v^2, $(g – a)/v^2$ is a constant.**
	Calculated value of **$(g – a)/v^2$ all correct**
	Since values are almost the same, hence true.
(c)(i)	Clear Workings shown with tangent drawn, Derivations showed that a = - 30 m s^{-2}

Table for (iv):

***t*/s**	***v*/ m s^{-1}**	***a*/ m s^{-2}**	**(*g* – *a*) / m s^{-1}**	**$(g – a)/v^2$ /10^{-3} m^{-1}**
3.0	28.5	6.90	3.10	**3.81**
6.0	43.2	**2.84**	**7.16**	**3.84**
9.0	48.0	1.20	8.80	**3.82**

(ii)	
	Graph for 1st 10 s correct trend (a decreasing from 10 to 0)
	Graph from 12 to 18 s correct trend
	Acceleration at t = 0, 11-12, 12, 16-18 s plotted correctly
8 (a) (i)	
	Shows decreasing amplitude throughout
	Period same or slightly longer (up to 1.5 T)
(ii)	Faraday's law state that the ***magnitude of the induced emf*** in a conductor (or circuit) is ***directly proportional to the rate of change of magnetic flux linkage*** experienced by the conductor (or linking the circuit).
	When the electromagnet is switched on, **as current flows through the coil, it generates a magnetic field**.
	The **oscillating** aluminium sheet **experience a change in magnetic flux linkage / cuts magnetic field lines**
	According to Faraday's law**, an emf will be induced** in the aluminium sheet.
	Since the aluminium sheet is a **conductor / metal**, **induced (***eddy***) currents**, circulates within it.
	The **mechanical energy of the oscillating system** has been **converted to electrical energy**, and dissipated as heat, hence damping occurs.
	(*Since amplitude of the oscillation is proportional to the mechanical energy, amplitude decreases continuously*.)

(iii)	
	Correct drawing and direction for,
	I
	$I_{induced}$ or eddy current (as shown)
	$B_{induced}$ (top section - towards electromagnet, bottom section – same direction)
	F_B upwards
(b)	The **strength of the magnetic field produced by the electromagnet depends on the current** following through it. (*The current can be adjusted by the variable resistor*.)
	As the **resistance of the variable resistor decrease**, current increases, hence the **strength of the magnetic field increase** and the **degree of damping increase** / **greater amt of electrical energy dissipated / more heat dissipated.**
	It will **reach a point when the aluminium sheet (or mass) return to its equilibrium position in the shortest time, without overshooting (or crossing) the equilibrium position**. This is called critical damping.
	To **detect** the point of critical damping, a marker is attached to the aluminium sheet which **traces** out the displacement vs time curve on a scrolling paper, mounted vertically.
(c)	For max B, needs max current, hence resistance of variable resistor = 0 Ω.
	$V = IR$ $15 = I(5.00)$ $I = 3.0A$
	At the centre of the solenoid, $B = \mu_o nI$ $= 4\pi \times 10^{-7} \times \frac{50}{0.0800} \times 3.0$
	$= 2.36 \times 10^{-3} T \quad (or\ 2.4 \times 10^{-3} T)$
	At one end of the solenoid, $B = \frac{1}{2}(2.36 \times 10^{-3})$ $= 1.18 \times 10^{-3} T \quad (or\ 1.2 \times 10^{-3} T)$
9	

(a)	Nucleon: constituent of a nucleus, can be either a proton or neutron Nucleus: positively charged centre of an atom, made up of protons and neutrons Nuclide: an atom with a particular proton-neutron combination (nuclear structure)
	Note: Isotopes are nuclides having the same number of protons but different number of neutrons
(b)(i)	Disintegration of a massive nucleus into smaller fragments of **comparable masses** with the **release of a large amount of energy**
	as the **total mass of the daughter products is lower than the parent nuclei**
(b)(ii)	${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n + energy$ Correct balanced equation Inclusion of energy
(c)(i)	**Minimum energy** required to break the nucleus into its separate nucleons such that the nucleons are separated to **infinity per nucleon/divided by total number of nucleons**
(c)(ii)	Daughter nuclei has **lower binding energy per nucleon** than parent nuclei (as can be seen from the BE/nucleon graph).
	and the **total mass of the daughter nuclei formed is more than the parent nucleus** which means that **energy has to be supplied** for the fission process to occur.
(c)(iii)	Energy released = Total *BE* of *Ba* and *Kr* - Total *BE* of *U*
	= [141(8.3) + 92(8.7)] – [235(7.6)]
	= **184.7 MeV**
	= 185 MeV
(c)(iv)	*KE* of daughter nuclei / *KE* of neutrons / γ rays
(c)(v)	Number of nuclear reactions = $(100 \times 10^{3}/0.235)(6.02 \times 10^{23}) = 2.56 \times 10^{29}$
	185 MeV = $(185\times10^{6})(1.6 \times 10^{-19}) = 2.96 \times 10^{-11}$ J
	Time = $(0.30)(100 \times 10^{3}/0.235)(6.02 \times 10^{23})(185\times10^{6})(1.6 \times 10^{-19})/ (6500 \times 10^{9} \times 60 \times 60)$
	= 97.2 = 97 yrs (2 s.f.)