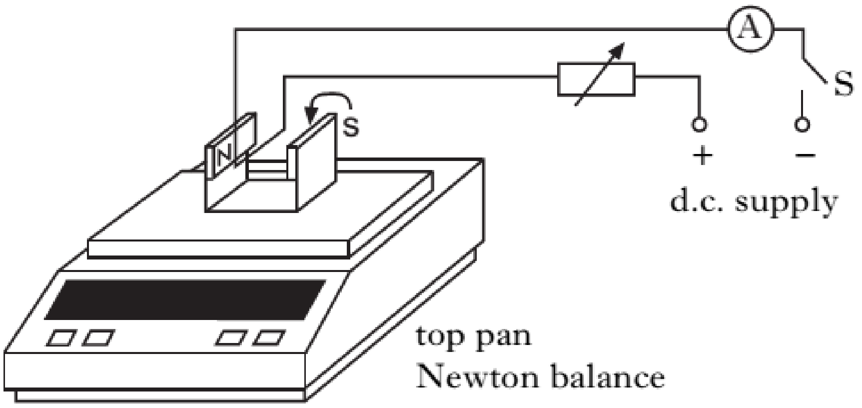
Higher Data Handling Questions

1. A student investigates the relationship between the force exerted **(F)** on a wire in a magnetic field and the current **(I)** through the wire to find the magnetic field strength **(B) in Tesla (T)**.

The force on a conductor equation is F = BILsinΘ.

(Θ – angle between the wire and the magnetic field)

A pair of magnets are fixed to a yoke and placed on a **Newton balance**. A rigid copper wire is suspended between the poles of the magnets. **The wire is fixed at 90° to the magnetic field** as shown below.



With the switch **S open** the **balance** is set to **zero**.

Switch S is closed. The resistor is adjusted and the force recorded for several values of current.

The results are shown in the table below.

Current I (A)	Force F (x 10^{-3}N)
0.30	0.45
0.60	0.90
0.88	1.35
1.00	1.50
1.40	2.13
1.68	2.50

a) Use the results in the table to plot a graph of the **force F against** the **current I**.

b) **Find the gradient** of the graph.

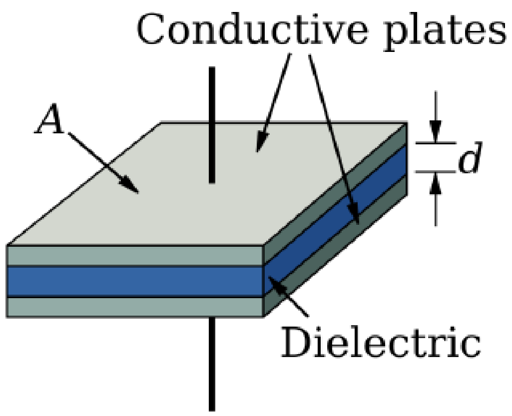
c) The length of the wire **(L)** in the magnetic field is **80mm**.

Use the **gradient of the graph** and the **force on a conductor equation** to find the magnetic field strength **B**, where B is measured in Tesla **(T)**.

2. The capacitance in Farads of a parallel plate capacitor is given the expression below.

$C = \varepsilon_o A / d$, where ε_o is the permittivity of free space, where air is the substance between the plates of the capacitor.

A is the area of overlap of the plates and **d** is the distance between the plates.



The following results were taken from an experiment with an **air filled** parallel plate capacitor.

Capacitance C (pF)	Area A ($\times 10^{-2}$ m^2)	Distance d ($\times 10^{-4}$m)
88	0.94	9.40
180	1.07	5.10
270	2.95	9.50
330	1.78	4.80
450	2.09	4.10

a) **Add another column** to the table of **A/d (m)**.

b) Use the results in the table to plot a graph of **C against A/d**.

c) Use the **gradient** of the graph to **find ε_o**, the permittivity of free space where air is the substance between the plates of a capacitor and compare to the accepted **$8.85 \times 10^{-12} Fm^{-1}$**.

d) The total permittivity **$\varepsilon_T = \varepsilon_r \times \varepsilon_o$** where **$\varepsilon_o$** is the permittivity of free space and **ε_r** is the relative permittivity of a dielectric substance that can be put between the plates.

The experiment is repeated using a capacitor filled with a dielectric of insulating oil and a similar graph is plotted.

Explain how the **gradient** of the graph will **differ** from the graph drawn in **c)**.

3. A **spiral spring** of **negligible mass** hangs vertically with a **mass m** attached to its lower end.

The mass m is raised slightly then allowed to fall.

Mass m

The spring obeys **Hooke's Law** expressed as **F = - kx** where **F** is the **tension** in the spring, **x** is the **displacement** from the rest position and **k** is the **spring constant**.

a) i) From **F = - kx**, sketch a graph of **F against x**.

ii) By equating **F = - kx** with Newton's Second Law where **F = ma,** find the equation linking the **acceleration a** with **x** the **displacement** of the spring from the rest position.

b) The **period T** of the oscillations is given by the equation,

$$T = 2\pi\sqrt{\frac{m}{k}}$$

assuming that the **mass of the spring is negligible**.

i) What will the **equation** be for **T^2**?

ii) Why is it useful to find T^2?

c) In an experiment to verify the equation above for the period of the oscillations, the following results were taken from the experiment:

Mass m (kg)	Observed Period T (s)
0.025	0.32
0.050	0.45
0.100	0.63
0.150	0.77
0.200	0.89
0.250	1.00

i) Add a column on to the table above titled **Observed Period squared T^2 (s)^2**.

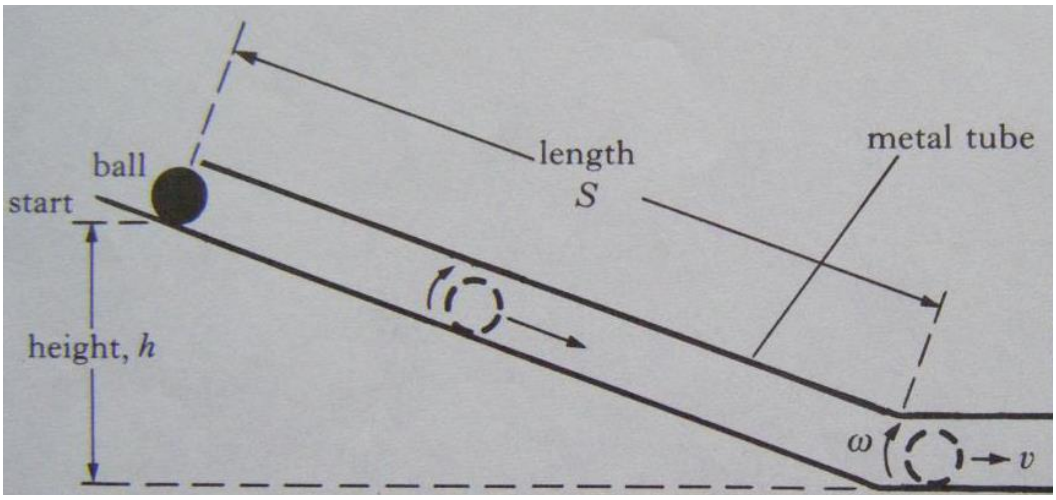
ii) Use the results in the table to plot a graph of **T^2 against m**.

iii) **Use the gradient of the graph** to find the spring constant **k** in **Nm^{-1}.**

4. Using the **principle of conservation of energy**, the **linear speed v** of a ball at the bottom of a slope is

$$v = \sqrt{\frac{10gh}{7}}.$$

The **height of the slope h** is varied and the linear speed **v** is recorded at the bottom of the slope.



A table of results was drawn as shown below to **find** the acceleration due to gravity **g**.

Height, h (m)	Linear speed of the ball, v (ms^{-1})
0.1	1.18
0.2	1.67
0.3	2.05
0.4	2.37
0.5	2.65

a) **Change the subject** of the equation to **g**, the acceleration due to gravity.

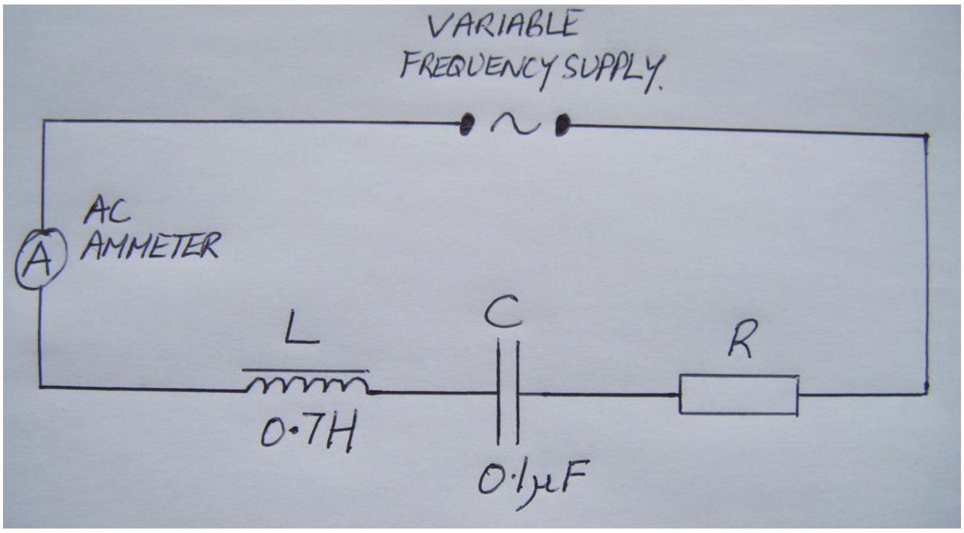
b) Use the results in the table to **plot a graph** of **v^2 against h**.

c) Find the **gradient** of the graph.

d) **Use the gradient** of the graph **to find** the acceleration due to gravity **g**.

e) How **could the experiment be improved** to find a more precise reading for **g**?

5. An ac supply can be connected to an inductor **(L)**, capacitor **(C)** and a resistor **(R)** in a **series LCR circuit** as shown below.



The opposition to the current flow in an inductor is called the **inductive reactance X_L**, where **$X_L = 2\pi fL$**. Inductance **(L)** is measured in Henries **(H)**.

The opposition to the current flow in a capacitor is called the **capacitive reactance X_c**, where **$X_c = 1/(2\pi fC)$**. Capacitance **(C)** is measured in Farads **(F)**.

The resonant frequency **f_o** can be found when **$X_L = X_c$**.

a) i) Equate the equations for **X_L** and **X_C** to find the equation for the resonant frequency **f_o**.

ii) Calculate the resonant frequency from the components in the above circuit.

b) The frequency of the ac supply was varied with the corresponding current readings recorded on the ac ammeter. The table below shows the readings of current and frequency recorded.

Frequency (Hz)	Current (mA)
140	10
420	45
570	90
620	92
700	62
840	30
980	12

i) **Draw a graph** of **current against frequency** from the data recorded in the table.

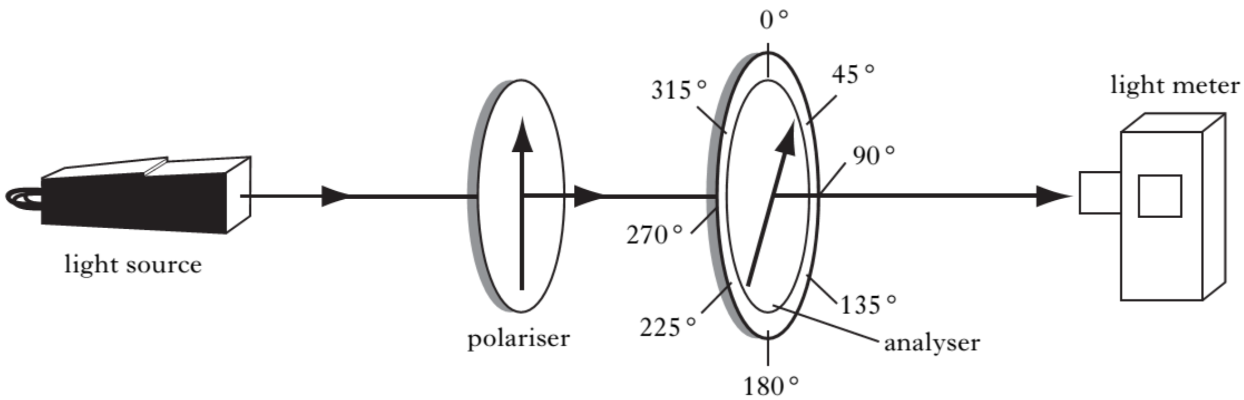
ii) Where is the **resonant frequency** calculated in **a) ii)** found **in this graph**?

iii) **What conclusion** can be drawn **from** the **graph**?

6. A light source produces a beam of unpolarised light. The beam of light passes through a **polarising filter called a polariser** to produce plane polarised light.

The plane polarised light passes through a **second polarising filter called an analyser**. The light irradiance passing through the analyser is measured by a light meter.

The transmission axis of the **analyser** can be **rotated** and its angle of rotation can be measured as shown below.



The following results were taken of light irradiance by varying the angle of rotation of the analyser.

Angle of Analyser Rotation (°)	Light Irradiance (Lux)
0	600
15	560
30	450
45	300
60	150
75	40
90	0
105	40
120	150
135	300
150	450
165	560
180	600

a) Draw a graph of **Light Irradiance (Lux)** against **Angle of Analyser Rotation (°)**.

b) Which **trigonometry function** does the shape of the graph follow?

c) What **three conclusions** can be **drawn** from the experiment?