Hong Kong Diploma of Secondary Education Examination

Physics and Combined Science (Physics)

School-based Assessment Sample Tasks

(Experiments and Investigative Study)

Teachers may use the sample tasks for non-profit making educational and research purposes with proper acknowledgement.

Name: ___________________

Chinese steelyard

Objective :

To make a Chinese steelyard to measure an unknown weight

Technique	
Set-up	
Accuracy	
Total	

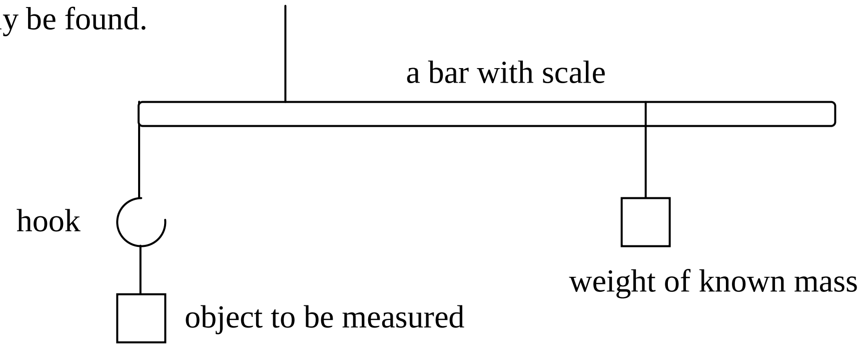
Apparatus:

Half-meter rule
100 g mass
Steel hook and nuts
Electronic balance
String
Adhesive tape
A pair of scissors
Stand and clamp

<u>Theory</u>

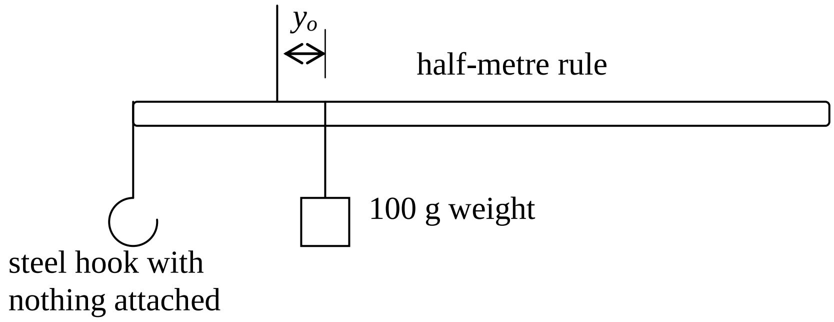
Chinese steelyard is a common measuring instrument in Hong Kong before 1980s. This is a clever application of lever system to measure weight precisely. The design of steelyard is a good example of how we apply engineering, science and mathematics in solving daily-life problems.

The steelyard has a horizontal bar which is hung by a string. The object to be measured is held by a hook at the tip. A weight of known mass is being shifted on the bar until the bar is balanced. By means of lever theory, the unknown weight of the object can easily be found.

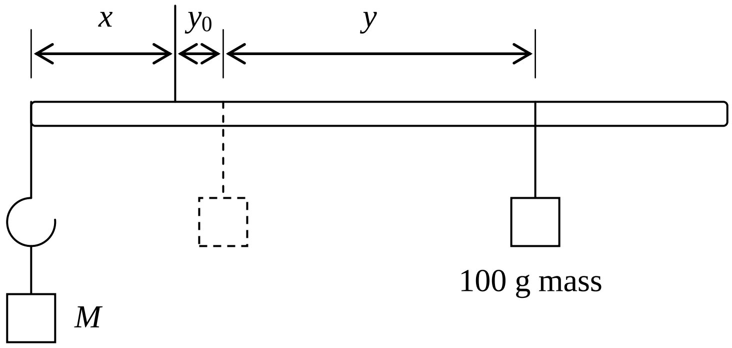


In this project, you are asked to design and make a steelyard and use it to measure an unknown mass. You are not required to mark scale on a bar. You just need to make use of the scale on the half-metre rule and calculate the unknown mass.

To find the unknown mass *M*, we must first balance the half-metre rule with the hook empty. We should record the 'zero position' y_0 of the 100 g weight.



When the unknown mass *M* is added to the hook, we have to move the 100 g weight to the right to restore equilibrium.



Mass *M* imposes an additional moment *Mgx* to the system. The movement of the 100 g weight imposes an additional clockwise moment of 0.1*gy* to the system. If the half-metre rule is restored to horizontal, the additional clockwise moment should cancel the additional anticlockwise moment.

$$\therefore \quad Mgx = 0.1gy$$

$$M = \frac{y}{x} \times 0.1 \text{ kg}$$

The key of a steelyard is that the half-metre rule must be balanced (i.e. in horizontal position) in the initial state. In reality, the half-metre rule, the hook and the known mass all have weight under gravity. To make them balance, you must do some calculation. You need to know the masses of the hook and the half-metre rule. This is the first step of your experiment.

You need to decide how large *x* and y_0 are. When doing the calculation, you can have more than one possible answer as you have one equation but with two unknowns. To decide what you should use is an engineering problem. You need to consider the accuracy and the range of the mass you have to measure. From the above equation, it is obvious that y increases when x increases for the same M. If you choose a larger x, you get a larger y. Your measurements have smaller percentage errors. If the value of y to balance is outside the half-metre rule, you cannot make the measurement. Therefore you need to compromise your design for these two requirements.

There are also some technical problems. For example you cannot tie a knot at the edge of the ruler. You need to leave a margin (e.g. 1 cm) so that you can tie a knot. Also it is preferred to use values that are easier to measure. Set x as 5.7 cm will not be a good idea as it is difficult to read and calculate.

Task

- The project is on individual basis. You do not need to form a group.
- Design and make a Chinese steelyard using the materials provided.
- Use the Chinese steelyard that you designed to measure an unknown mass M. The unknown masses of different groups are not the same. They all lie between 300 to 500 g.
- Marks of 0 – 20 will be given. 6 marks will be for the proper procedures and a successful set-up. 14 marks will be awarded for how accurate the final answer is.

Percentage error	Mark
$0 \le$ error $\le 2\%$	14
$2\% <$ error $\le 4\%$	12
$4\% <$ error $\le 6\%$	10
$6\% <$ error $\le 8\%$	8
$8\% <$ error $\le 10\%$	6
$10\% <$ error $\le 15\%$	4
$15\% <$ error $\le 20\%$	2
Error $> 20\%$ or setup fail	0

- You do not need to submit any report. Marks will be given just by checking your set-up and the answer of M you submitted.
- Time of experiment

  14/5 F.4BCD

  17/5 F.4A round 1

  18/5 F.4A round 2

  All experiment sessions are 3:30 to 5:00 p.m. You may leave once you have finished.

For more instructions of the experiment, refer to the video in Youtube.

Chinese steelyard - Introduction
https://youtu.be/AXiNZl4XsKk

Chinese steelyard – Calculation
https://youtu.be/SmH_-XB8C1Q

Chinese steelyard - Experiment
https://youtu.be/CYQnWLkUu3U

Name: ____________________ Group No: _______

Focal length of a convex lens

Technique	
Result	
Discussion	
Conclusion	
Total	

Objective:

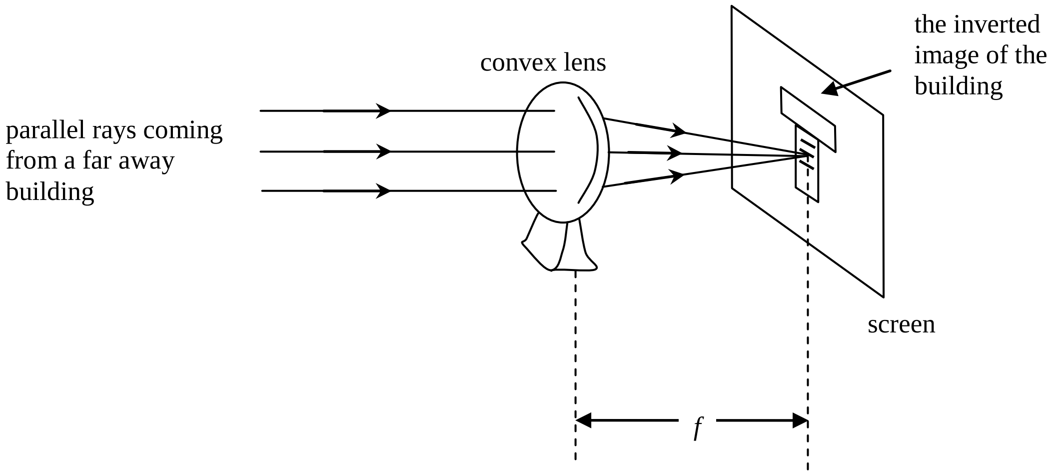
To measure the focal length of a spherical convex lens.

Apparatus: spherical convex lens with holder
lamp housing and object
translucent screen
metre rule and half-metre rule
12 V power supply
2 connecting wires

Method I — Forming image of a distant object

Procedures:

1. Hold the convex lens near a window. Move the translucent screen to a position where a sharp image of a distant object can be formed as shown below.



2. Measure the distance between the lens and the screen. This is the focal length of the lens.

Results:

The focal length found using Method I, f_1 = _____________ cm

https://youtu.be/ybkG0Hx

Method II — Using lens formula

Procedures:

1. Prepare the set-up shown below. Set the distance between an illuminated object and the lens, i.e. the object distance u, to a value equals to $2f_1$.

2. Adjust the position of the translucent screen until a sharp image is formed on it and measure the distance between the lens and the screen, i.e. the image distance v.
3. Change the object distance u to some values larger than $2f_1$ and repeat the measurement to obtain 3 more pairs of u and v. Remember u should be chosen so that $\frac{1}{u}$ .should spread over a reasonable range in your graph in step 5.
4. Change the object distance u to some values smaller than $2f_1$ and repeat the measurement to obtain 3 more pairs of u and v.
5. Plot a graph of $\frac{1}{v}$ against $\frac{1}{u}$. You will use the x and y- intercepts of the graph to find the focal length of the lens in discussion part.

Results:

	u / cm	v / cm	$\frac{1}{u}$ / cm^{-1}	$\frac{1}{v}$ / cm^{-1}
$u < 2f_1$				
$u = 2f_1$				
$u > 2f_1$				

<u>This is a blank page</u>

Name: ____________________ CSNO: ________

Discussion:

1. State the nature of the images formed in different steps of Method II.

   Step 3: ____

   Step 4: ____

2. Referring to the lens formula $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$, what should be the expected shape of the graph when $\frac{1}{v}$ is plotted against $\frac{1}{u}$? Explain briefly.

   ____

   ____

   ____

   ____

   ____

   ____

   ____

3. Find the focal length of the lens from the graph. Show your method below.

   ____

   ____

   ____

   ____

   ____

   ____

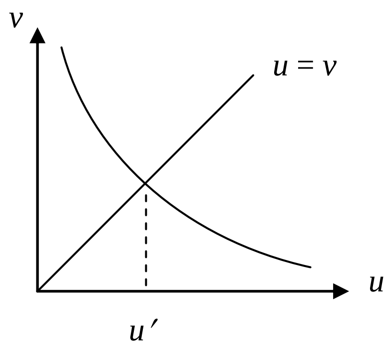
   ____

f = ____________________ cm

4. Give one major source of error in Method II.

5. Can we use Method I or Method II to find the focal length of a concave lens ? Explain briefly.

6. If a graph of v versus u is plotted, we can find the focal length f by adding a line $v = u$ on the graph.



(a) Explain how you can use the value of u' of the intersection to find f.

(b) Explain why the method in step 3 is a more accurate way to find *f* than the method in step 6(a).

- END -

Name: ______________________ Group: ____________

Force on current-carrying conductor in a magnetic field

Objective:

To investigate the relation between the current and force acting on a current-carrying conductor in a magnetic field.

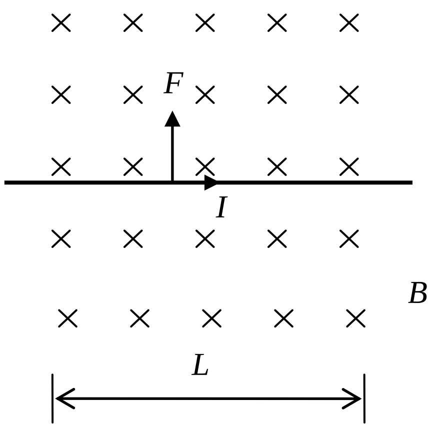
Apparatus:

- Electronic balance
- 1 A ammeter
- Magnet
- Rheostat
- 3 V battery
- Stand and clamp
- Conducting wires
- Wooden block with rubber band
- Ruler
- Component holder

Technique	
Result	
Discussion	
Conclusion	
Total	

Theory

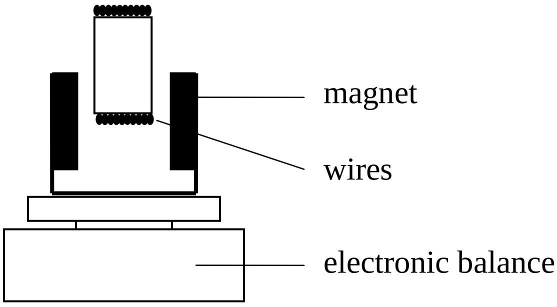
When a current-carrying conductor is placed inside a magnetic field, a force is induced. According to Fleming's left hand rule, the force, the magnetic field and the current are perpendicular to each other.



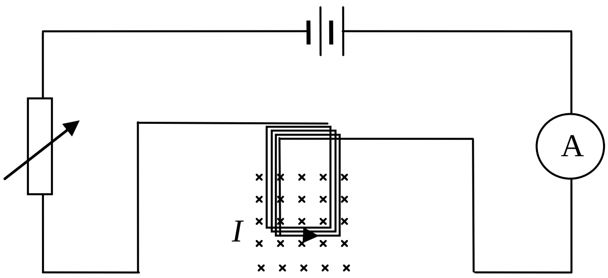
The magnitude of the force F depends on factors like the magnetic field strength B, the current I and the length L of the conductor in the magnetic field. In this experiment, you are going to find the relation between the force F, the length L and the current I.

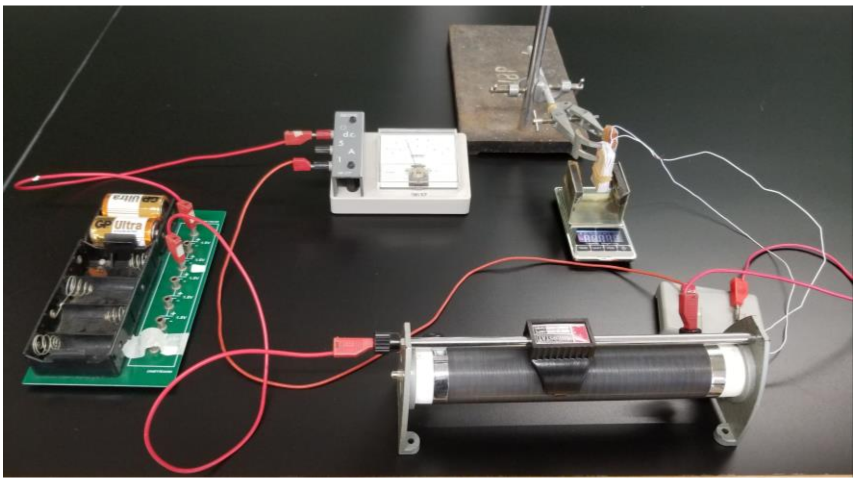
Procedures:

1. Place the magnet on the electronic balance.
2. Wound 10 turns of wire on a wooden block. Fix the wire with a rubber band so that the wire is tightly mounted on the block. Measure the length of the wire L_0 on the short side of the block. The total length L of the wire in the magnetic field is equal to $10L_0$.
3. Insert the block into the space between the pole pieces of the magnet. Fix the block with the stand and clamp. The short side of the block should be placed horizontally along the middle line of the magnet so that the wires are perpendicular to the magnetic field as shown.



4. Switch on the electronic balance. Set the reading to zero by pressing the button ‘tare’. The electronic balance is set and can be used to measure the change in the downward force acting on its pan.
5. Connect the wire to a battery through the rheostat and the ammeter. **Make sure the rheostat is set to its maximum resistance.**





6. Adjust the rheostat until the ammeter reads 0.2 A. Take the reading shown on the balance.
7. If the balance shows a negative reading, the current is in a wrong direction and the force on the magnet is upward. Disconnect the battery and reverse the poles to give a downward force.
8. Repeat the experiment by increasing the current in steps of 0.2 A until 1.0 A is reached. Put down the readings in the table below. To avoid making the battery flat, disconnect the battery once you have taken each of the readings.
9. Connect the battery and set the current to 1.0 A again. Take the reading of the balance.
10. Repeat the experiment by reducing the number of turns of wire on the wooden block in steps of 2 turns until just two turns are left. Keep the current at 1.0 A throughout the experiment. Put down the readings in the table below. Disconnect the battery once you have taken the reading.

Briefing of experiment

https://youtu.be/1tKIM9yqb7Y

Results

Take g = 9.81 m s^{-2}

Length of the short side of one turn of wire L_0 on wooden block = ____________________ cm

1. Number of turns of wire = 10

   Length of wire in the magnetic field = 10 × L_0 = ______________________ cm

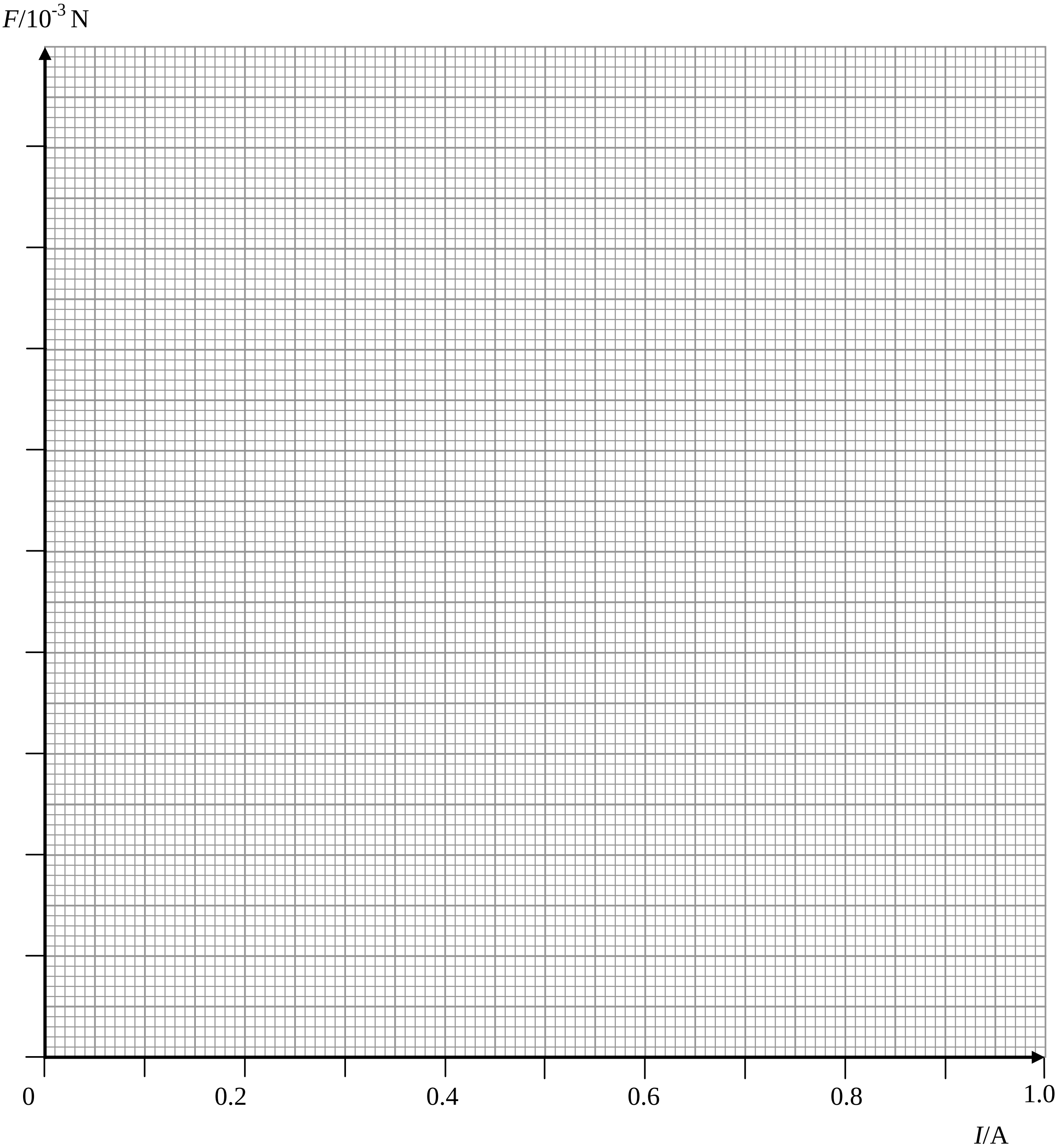
Current I/A	0.2	0.4	0.6	0.8	1.0
Balance reading m/g					
Force acting on the wires $F/10^{-3}$ N					

   Plot a graph of F versus I in the graph below.

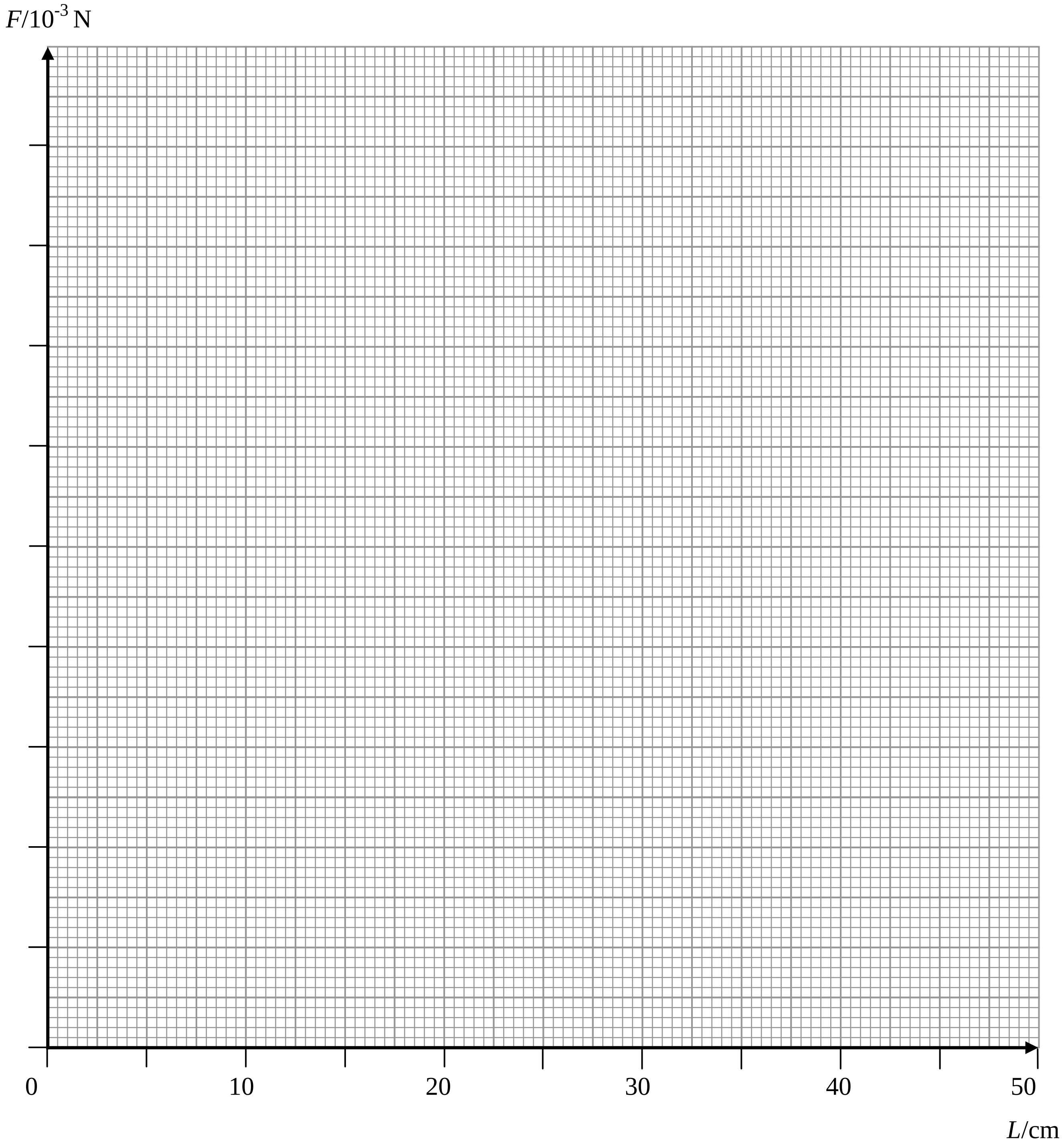
2. Current I = 1.0 A

Number of turns N	2	4	6	8	10
Length of wire in the magnetic field L/cm					
Balance reading m/g					
Force acting on the wires $F/10^{-3}$ N					

   Plot a graph of F versus L in the graph below.



What is the relation between the force F and the current I?



What is the relation between the force F and the length L?

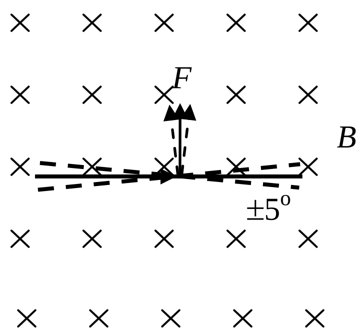
Discussion

1. Express the slope of the graph F versus I in terms of B. Use your graph to find the value of B at the position where you place the wires.

2. The Earth has a constant magnetic field of order of 10^{-3} T. In the experiment to find the relation among F, I and L, do you think that the magnetic field of the Earth would affect your finding ? Explain briefly.

3. The electronic balance actually measures the downward force experienced by the magnet. Explain why this reading also represents the force acting on the wires.

4. We assume that the wires are placed horizontally and the magnetic force is vertical. As we make the judgment visually, it is possible that the wires are not perfectly aligned. Therefore the vertical force produced is smaller than *ILB*.



An average people can keep the error of alignment within ±5°. Comment whether this error in *F* is more significant as comparing to the other sources of errors (such as error in *L* and error in *I*). You should do some calculation to support your answer.

- END -