
Effects of forces
Hooke's law-resultant forces

Force: A force is defined as a push or a pull.

Effects of forces:

- Force may change the size and the shape of a body.
- It can make an object move or stop a moving object.
- It can accelerate an object .
- It can decelerate an object.

Extension-load graphs:

Attach weights to the free end of a spring. As the force increases the extension of the spring also increases. For particular values of the force , tabulate your observations. Record the weight attached and the extension caused by it.

Note: Extension: It is the difference between the original length(unstretched length) and new length(stretched length)

Then plot a graph of force(weight) in N against extension in mm.

Hooke's law: The extension of a spring (x) is directly proportional to the load (F) it supports , provided the spring has not crossed its elastic limits.

$F \propto x$. Hence $F=k(x)$ where k= spring constant

Elastic limit:(limit of proportionality): It is the point where the proportionality between the force(weight) and the extension stops.[1m]

The weight is a force that stretches the spring.

Suppose these are the observations of four students on Hooke's law .

	student A	student B	student C	student D
load/N	spring length/cm	spring length/cm	spring length/cm	spring length/cm
0.5	6.7	9.2	9.1	10.0
1.0	7.7	10.0	9.9	11.1
1.5	8.7	10.8	10.7	12.2
2.0	9.7	11.6	11.5	13.3
2.5	10.7	12.6	12.3	14.4
3.0	11.7	13.8	13.1	15.5
3.5	12.7	15.2	13.9	16.6
4.0	13.7	16.8	14.7	17.7

Student A :

- For every 0.5N, the extension is 1cm.
- This indicates original length of the spring for 0N is 6.7-1=5.7cm.
- Spring has not crossed its elastic limit as extension is in proportion to the force applied.

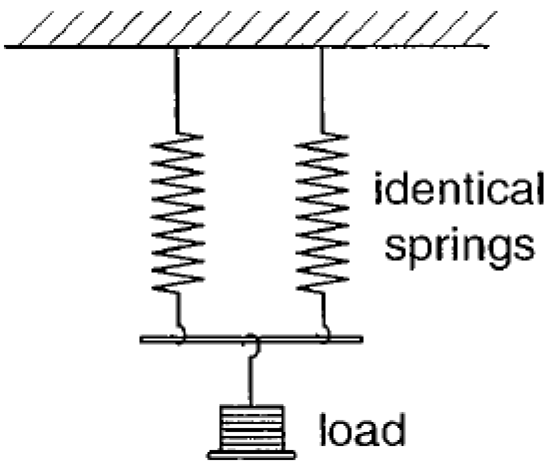
Student B:

- For every 0.5N that are added, the extension is 0.8cm
- The spring has crossed its elastic limit when a weight of 2.5N is attached to it.

Student C and D:

- The extensions are in proportion to the weights attached.
- The springs have not crossed their elastic limit

When a weight is attached to two springs as shown below:



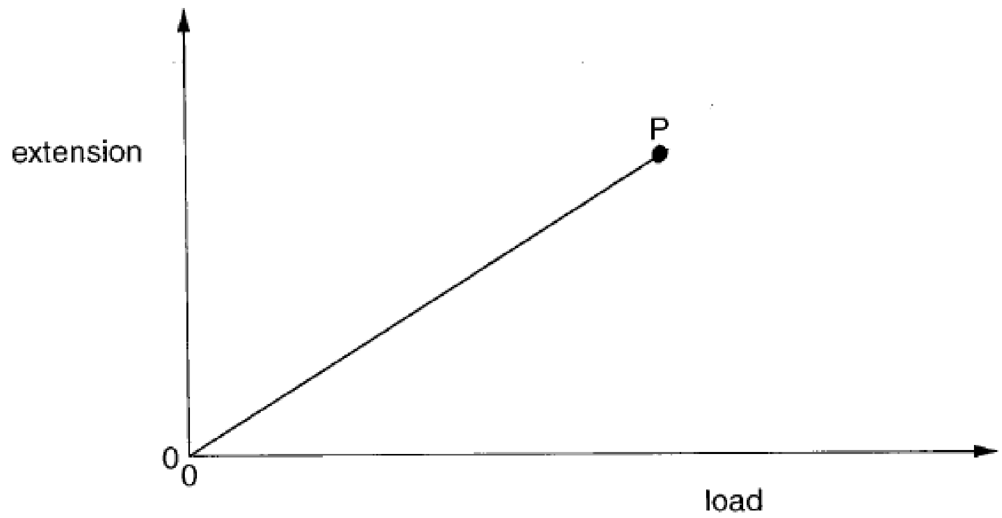
Note: Each spring experiences half the load.

Find the length of each spring ,when it is loaded with a weight of 2.5N. we can make use of the observation table.

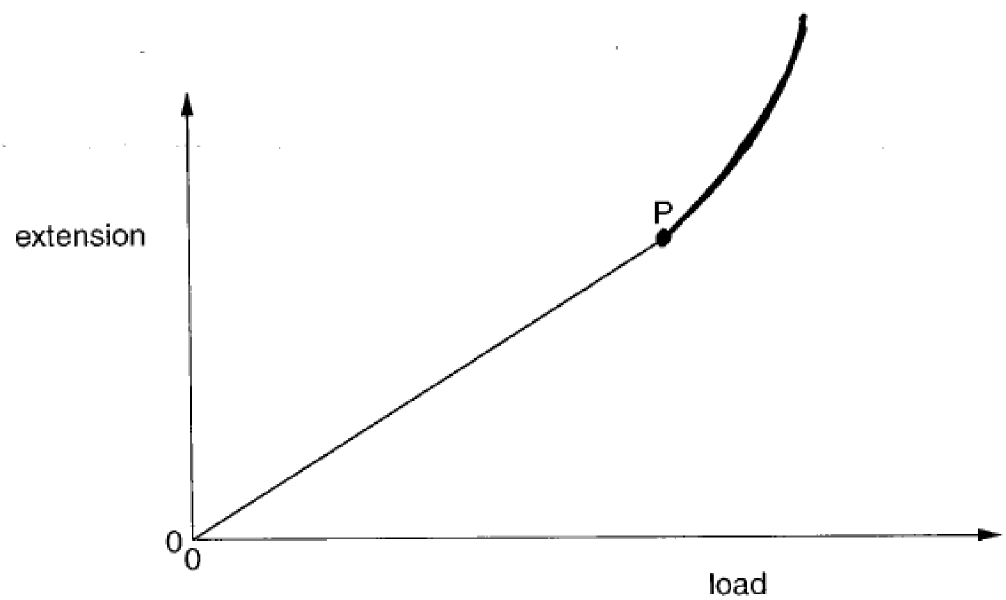
1.25N is between 1.0 and 1.5N will produce an extension of $\frac{7.7+8.7}{2}$ =8.2N

You might be required to continue to plot a part of the graph

Example: Suppose point P is the elastic limit, Continue the graph beyond P.



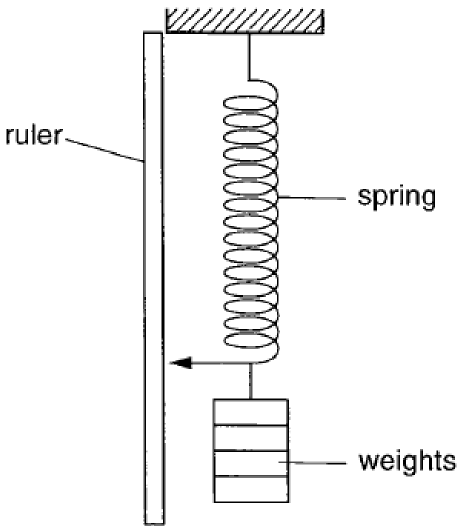
Solution would be like the one shown below.

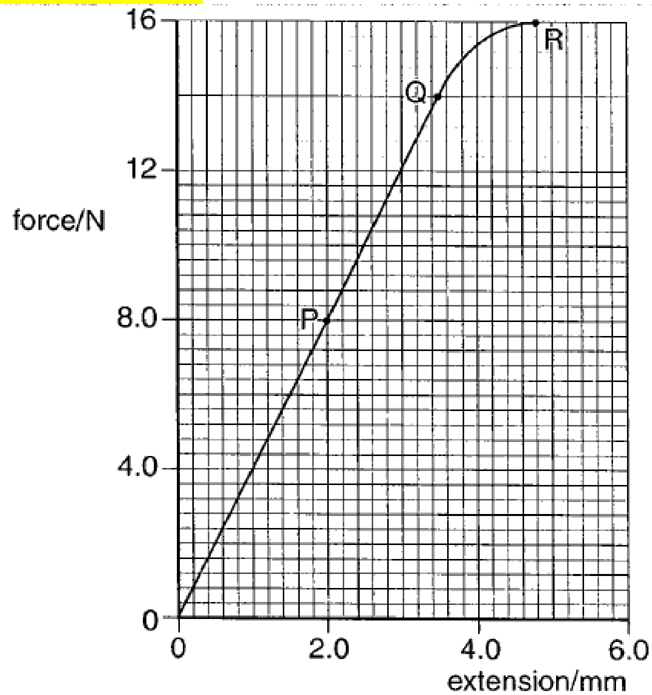


Note:

- The graph has to curve upwards as the spring will show a large extension as it has crossed its elastic limit.
- Also you know that the spring obeys Hooke's law because the graph is a straight line graph passing through the origin.
- Also the shape of the graph beyond P is described as non-linear.

The following is another representation of the Hooke's law where a graph of Force(weight) is plotted against the extension.

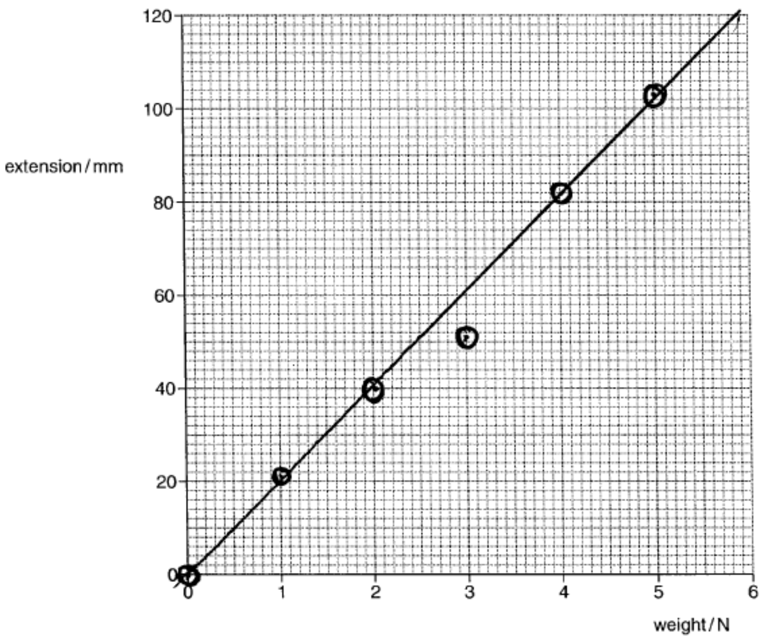




Note:

- Between OQ , Hooke's law is obeyed.
- Between QR , the extension per unit force is reduced.
- Hooke's law states that $F \propto x$. Hence F=k(x) The value of k can be found out using the graph by diving any y coordinate by its corresponding x coordinate between the region OQ. Example: $\frac{8}{2} = 4$
- Remember k=spring constant. its value is fixed for a particular spring.
- Also note that a particular reading may not fall on the graph. This is due to an experimental error.

You may be asked to estimate



Will adding a 45N load produce an extension of 920mm?

You must know that such an estimate will be unrealistic as the spring will have crossed its elastic limit by then.

Resultant of forces:

When more than one force acts on an object, we can calculate the combined effect of all the forces as a single force. This single force is called as the resultant force.

Two cases of resultant forces acting along the same line:

- **When the resultant force is zero:**

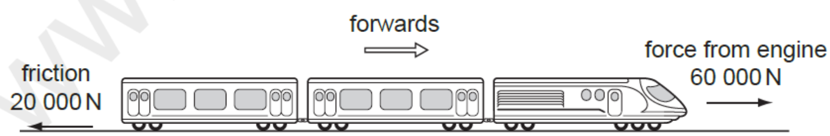
➢ Then the object will remain at rest if it is already at rest.

➢ The object will move at the steady speed and in the same direction if it was already moving.

- **When the resultant force is non-zero:**

Example:

9 A train is travelling along a horizontal track at constant speed. Two of the forces acting on the train are shown in the diagram.



A force of air resistance is also acting on the train to give it a resultant force of zero.

What is this air resistance force? **0625/01/O/N/08**

A 40 000 N backwards

B 80 000 N backwards

C 40 000 N forwards

D 80 000 N forwards

Note: If only two forces would have acted on the engine, then the net resultant force would have been 40 000N forwards. But the air resistance is also acting on the train such that the net force is zero. hence the air resistance must be equal to 40 000N backwards .

[Forward force= backward force]-Ans: A

APPLICATION BASED QUESTIONS:-MCQ

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6 Which statement about a moving object is correct? **0625/12/M/J/10**

A When an object is accelerating, the resultant force acting on it must equal zero.

B When an object is moving at a steady speed, the air resistance acting on it must equal zero.

C When an object is moving at a steady speed, the resultant force acting on it must equal zero.

D When an object is moving, there must be a resultant force acting on it.

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8 In which of these situations is no resultant force needed? **0625/1/O/N/02**

A a car changing direction

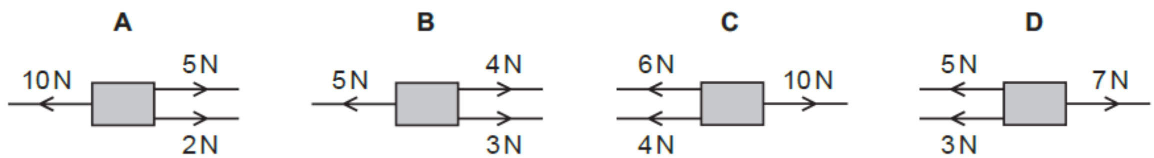
B a car moving in a straight line at a steady speed

C a car slowing down

D a car speeding up

0625/12/O/N/11

6 Which combination of forces produces a resultant force acting towards the right?



Hint: Add the LHS forces and RHS forces. The resultant would be the difference between the greater force and smaller forces and in the direction of the greater force.

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7 A box is being moved by a fork-lift truck. The total weight of the box is 3000 N.

0625/12/O/N/13

The force exerted by the fork-lift truck on the box is 3500 N upwards.

What is the resultant force on the box?

A 500 N downwards

B 500 N upwards

C 6500 N downwards

D 6500 N upwards

APPLICATION BASED QUESTIONS:-EXTENDED THEORY:

O/N/2017-P42

2 **(a)** An object is moving in a straight line at constant speed. A resultant force begins to act upon the object.

State the ways in which the force may change the motion of the object.

It may accelerate the object

or it may change the direction of the object

....

....[2]

(b) State **one** other effect a force could have on the object.

It can change the shape of the object ....[1]
