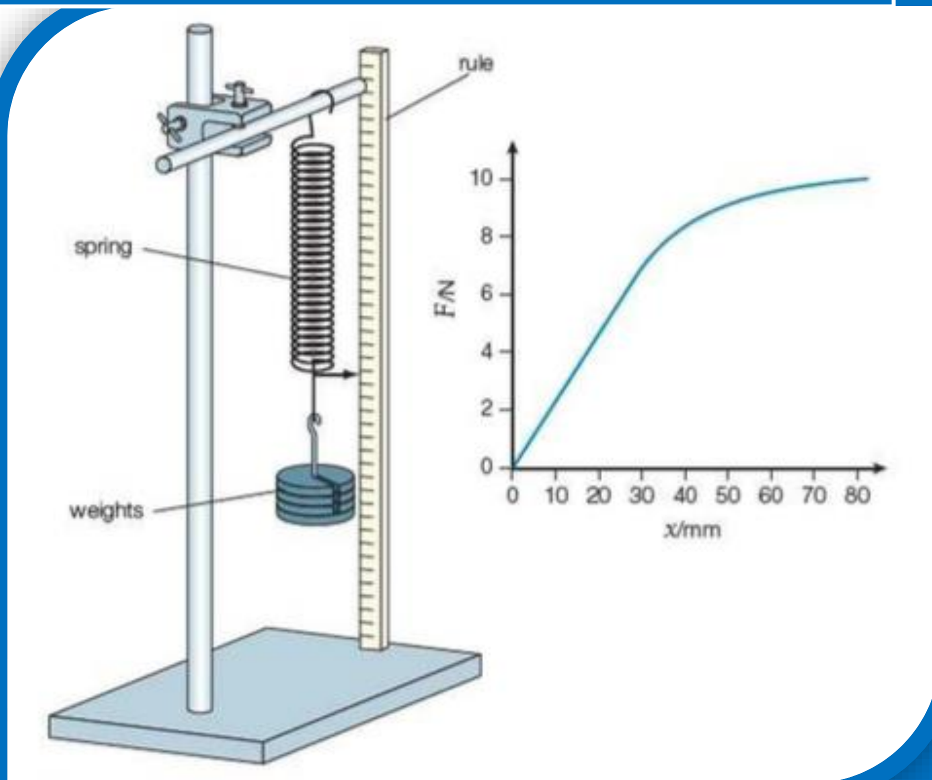
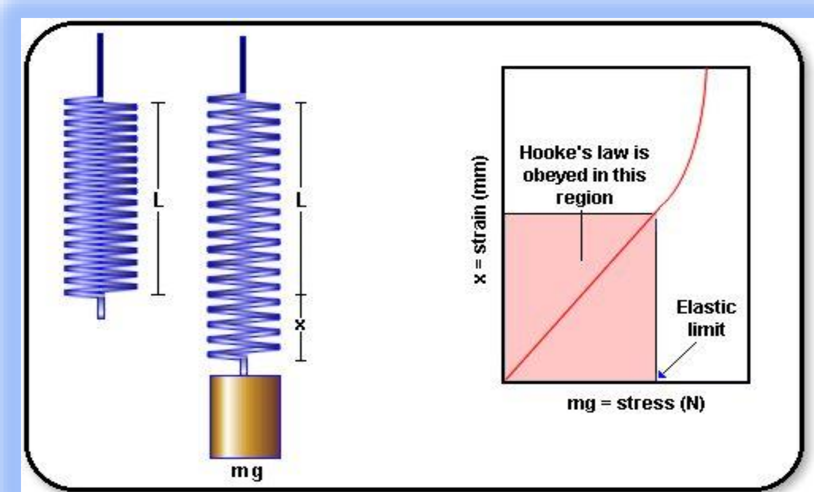
KNOWLEDGEBASE PHYSICS

2020

HOOKE'S LAW





TEACHERS OF PHYSICS
www.teachersofphysics.com
9/20/2020

1. State **Hooke's** law **(1mk)**

✓ For a helical spring or any other elastic material, extension is directly proportional to the stretching force, provided elastic limit is not exceeded

2. Define the term elastic limit, as used in stretching of materials (1mk)

✓ The point beyond which the elastic material does not obey Hooke's law

3. State the **SI** units of elastic constant of a spring **(1mk)**

✓ Newton per meter (N/m)

4. State the features that govern the strength of a spiral spring of a given material. (2mks)

Strength of a spring is the ability of a material to resist breakage when under stretching, compressing or shearing force. A strong material is one which can withstand a large force without breaking. Hence the strength depends on:

i. Diameter of the spring
ii. Diameter of the wire making the spring
iii. Number of the coils of the spring
iv. Nature of the material making the spring

5. State two factors on which the extension of a wire depends on assuming it obeys Hooke's Law. (2mks)

i. Length of the wire
ii. Load
iii. Nature of the wire (spring constant)

6. Apart from the diameter and length, name another factor that determines the spring constant of a spiral spring. (1mk)

i. Type of material making the wire
ii. The number of turns per unit length of the spring

7. A heavy load is suspended on a wire. Give any one factor that will determine extension in the wire. **(1mk)**

i. Length of the wire
ii. Nature of the wire (spring constant)

8. Distinguish between ductile end and brittle material

Ductile materials elongate considerably when under stretching forces and undergo plastic deformation until they break e.g. lead, copper, while **Brittle materials** do not undergo extension and break without warning on stretching. E.g. blackboard chalk, bricks, cast iron, glass, and dry biscuits.

9. It is easier to bend an iron rod than a glass rod of the same dimensions at room temperature. Give a reason for this

Iron is a ductile material while glass is a brittle material.

 Copyright © 2020

10. A spiral spring stretches by **0.6 cm** when a mass of **300g** is suspended on it. What is the spring constant?

F=ke

e = 0.006m

F=mg= 0.3×10=3

$k = \frac{3}{0.006}$ = 500N/m

11. An unloaded spring has a length of **15cm** and when under a load of **24N** it has a length of **12cm**.What will be the load on the spring when length is **10cm**?

$F = ke$

F=24N

E= 0.03m

k= $\frac{24}{0.03}$ = 800N/m

F= 800×0.05

=40N

12. An object of weight **20N** attached at the end of a spring causes an extension of **0.5 cm** on the spring.

(a) Determine the spring constant. (2mk)

K= $\frac{20}{0.005}$ = 4000N/m

(b) Determine the weight of an object that would cause an extension of 0.86 cm on the same spring. (1mk)

$F = ke$

= 4000×0.0086

= 3.44N

13. A copper wire is **2m** long. A force of **4N** suspended on the wire while other end is fixed increases its length to **2.001m**. **What** force would make the length of the wire **2.032m**? (3mks)

$k = \frac{F}{e}$

$= \frac{4}{0.001}$

= 4000N/m

$F = ke$

= 4000×0.032

=128N

14. The pointer of an unloaded spring reads **32 cm**. when a mass of **120g** is applied to the spring, the pointer reads **38cm**. a pan in which a mass of

Copyright © 2020
www.teachersofphysics.com

210g is placed is now hang from the spring and the pointer reads **48cm**. determine the mass of the pan. (4mks)

F=1.2N and e= 0.06 hence $k = \frac{F}{e} = \frac{1.2}{0.06} = 20N/m$

$F = ke$

$= 20 \times 0.16$

$= 3.2N$

Weight of the pan = 3.2-2.1 =1.1N

Mass of the pan = $\frac{1.1}{10}$ = 0.11Kg = 110g

15. Two identical helical springs are connected in series. When a **50g** mass is hang at the end of the springs, it produces an extension of **2.5 cm**. Determine the extension produced by the same mass when the springs arc connected in parallel. (3mks)

$K_s = \frac{F}{e}$ where e is total extension

$= \frac{0.5}{0.25}$

$= 2$ N/m

$K_1 = 4$N/m

$k_p = 8$N/m

$e = \frac{F}{k} = \frac{0.5}{8} = 0.0625$m =6.25cm

16. Two springs of negligible weights and spring constants 50N/m and 75N/m respectively are connected in series and suspended from a fixed point. Determine the total extension when a mass of 7.5kg is hung from the lower end. (3mk)

$e_t = e_1 + e_2$

$e_1 = \frac{F}{K1}$

$= \frac{75}{50} + \frac{75}{75}$

$= 1.5 + 1$

$= 2.5$m

17. Two springs of negligible weight and of spring constants **100Nm^{-1}**respectively are connected end to end and suspended from a fixed point. Determine;

(i) The total extension when a mass of **7.5 kg** is hung from the lower end. (2mk)

$e_t = \frac{F}{ks}$

$= \frac{75}{50}$

$= 1.5$m

(ii) The elastic constant of the combined of springs. (2mk)

Copyright © 2020

$K_s = \frac{1}{2}k_1$

$= \frac{1}{2} \times 100$

$= 50\ N/m$

18. A spring extends by 6cm when supporting a mass of 0.06kg on earth. When the spring is used to support the same mass on the moon, it extends by 1 cm. determine the moons gravitational strength. (*take the gravitational field strength on earth as 10N/kg*) (3mk)

$K = \frac{F}{e}$

$= \frac{0.6}{0.06}$

$= 100N/m$

$F = ke$

$= 100 \times 0.01$

$= 1N$

But $F = mg$

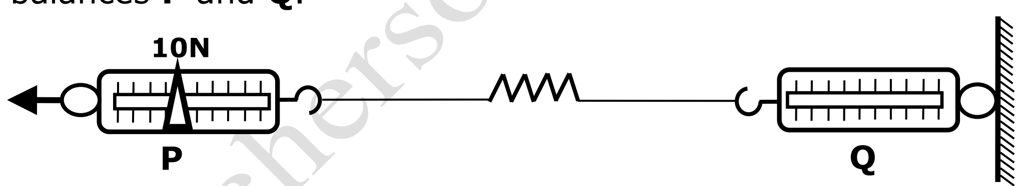
$1 = 0.06 \times g$

$g_{moon} = \frac{1}{0.06}$

$= 16.67\ N/kg$

SPRINGS

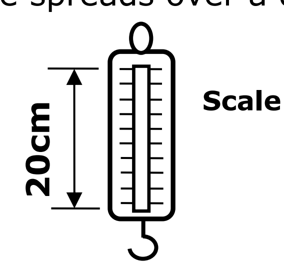
1. Fig below shows a stretched spring held in position by two identical spring balances **P** and **Q**.



What will be the reading on spring balance **Q**? (1mk)

10N they are sharing the same load and are arranged in parallel with respect to the load.

2. The figure below shows a spring balance. Its spring constant is $125Nm^{-1}$. The scale spreads over a distance of 20cm.



Determine the maximum weight that can be measured using this spring. 3mk

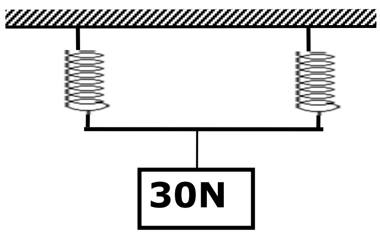
$F = ke$

www.teachersofphysics.com

$= 125 \times 0.2$

$= 25N$

3. The identical springs of spring constant **3N/cm** are used to support a load of **30N** as shown.



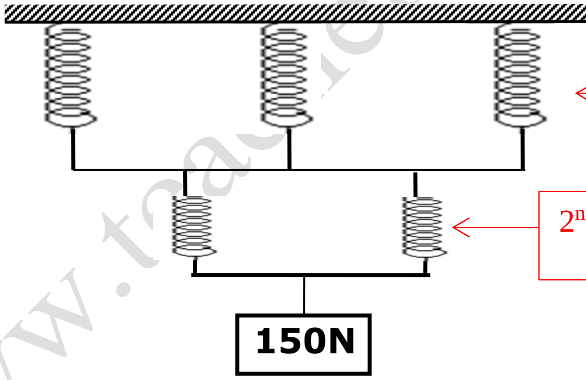
Determine the extension on each spring (3mks)

$K_p = 2k_1 = 6N/cm$

$e = \frac{F}{kp} = \frac{30}{6} = 5\ cm$

4. The spiral springs shows in the figure below are identical. Each spring has a spring Constant **K=100N/m** Determine the total extension caused by the **150N** weight.

(3mk)



$1^{st}\ Kp = 3k_1 = 300N/m$

$2^{nd}\ K_P = 2K_1 = 200N/m$

$K_s = 1^{st}\ k_p + 2^{nd}\ K_p$

$= 300+200$

$= 500N/m$

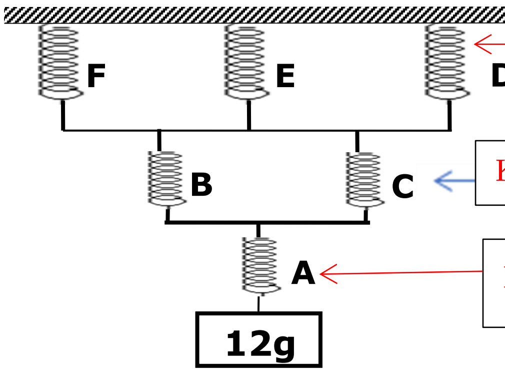
$E = \frac{F}{ks}$

$= \frac{150}{500} = 0.3\ m$

www.teachersofphysics.com

 Copyright © 2020

5. Figure shows a mass of **12g** suspended on a set of **6** identical springs. When the mass was hanged on spring **A**, it extended by 5cm.



Kp = 7.2N/m

Kp = 4.8 N/m

$K = \frac{F}{e} = \frac{0.12}{0.05} = 2.4$ N/m

Determine the extension of the combination shown if each spring and rod has negligible weight.
(3mks)

F= 0.12 N

Ks = 7.2+ 4.8+ 2.4

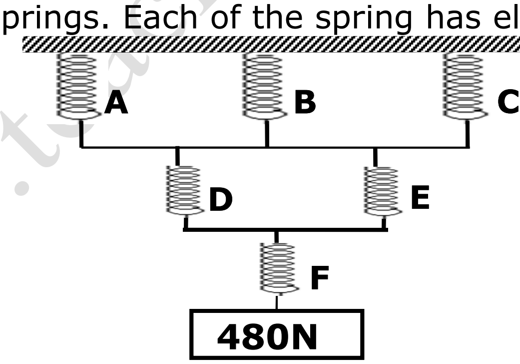
=14.4 N/m

$E = \frac{F}{ks}$

$= \frac{0.12}{14.4}$

= 0.00833m.

6. The diagram below shows a force of **480N** hanged on a set of 6 identical springs. Each of the spring has elastic constant **100N/m**.



Can further be discussed not so sure.

Determine

(i) The extension of springs **A, B, C** **(2mk)**

www.teachersofphysics.com

 Copyright © 2020

$K_p = 3k_1$

$= 300N/m$

$e_t = \frac{F}{Kp} = \frac{480}{300} = 1.6m$

(ii) The extension of springs **D, E** **(2mk**

$K_p = 2\ k_1$

$= 200N/m$

$e_t = \frac{480}{200} = 2.4m$

(iii) The extension of spring **F. (2mk**

$e = \frac{F}{k}$

$= \frac{480}{100}$

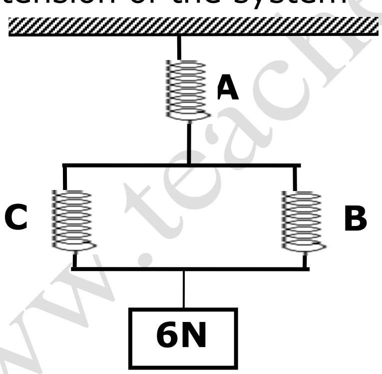
$= 4.8m$

(iv) The total extension of the system **(2mk)**

$eT = 1.6 + 2.4 + 4.8$

$= 8.8m$

7. Three identical springs each of spring constant 10N/M and weight 0.5N are used to support a load as shown. Determine the total extension of the system (2mk



$e_A = \frac{7}{10}$

$= 0.7m$

$e_p = \frac{6}{20}$

$= 0.3\ m$

$e_T = 1m$

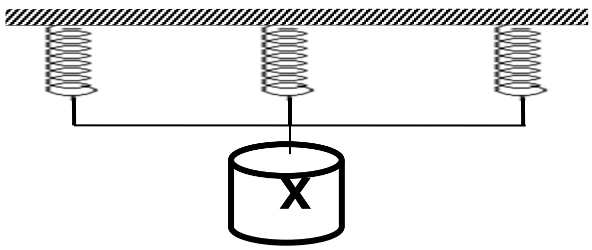
 Copyright © 2020

8. (i) A light spring fixed at one end extends by 2.0cm when a weight of 120g is suspended from the free end .Use this information to answer question 7 and 8.

(ii) Find its spring constant. (1mk)

$$K = \frac{F}{e} = \frac{1.2}{0.02} = 60N/m$$

(iii) Three such springs are arranged in a manner shown in figure 5 below and used to support a load If each extends by 2.0cm, what is the weight of the load? (2mks)

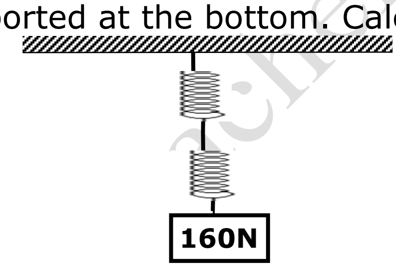


$F = ke$

$= 180 \times 0.02$

$= 3.6\ N$

9. Two springs of negligible weight and elastic constants of **800N/m** and **400N/m** are arranged as shown below with a load of **160N** supported at the bottom. Calculate the total extension of the springs.



$K_s = k_1 + k_2$

$= 800+400$

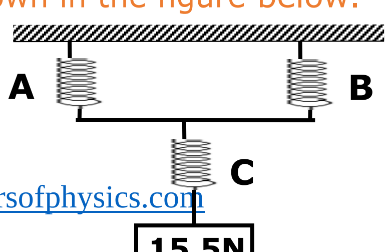
$=1200N/m$

$e= \frac{F}{ks}$

$= \frac{160}{1200}$

0.133m

10. Three identical springs **A, B** and **C** are used to support a **15.5N** weight as shown in the figure below.



teachersofphysics.com

Copyright © 2020

If the weight of the horizontal beam is **0.5N**, determine the extension of each spring given that **4N** causes an extension of **1cm**. (3mks)

$K_T = \frac{F}{e} = \frac{4}{0.01} = 400N/m$

$K_A + K_B = 400 + 400 = 800N/m$

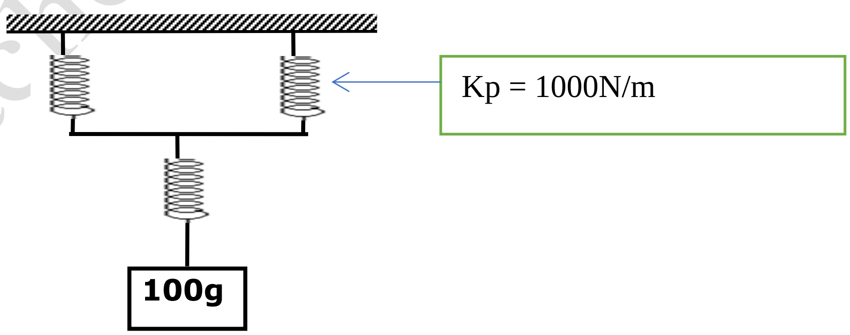
$F = Ke$

$e_{a,b} = \frac{16.0}{800} = 0.02m$

$K_C = 400N/m$

$e_c = \frac{15.5}{400} = 0.039m$

11. Three identical springs, each of mass 20g, are joined together as shown below and support a mass of 100g.



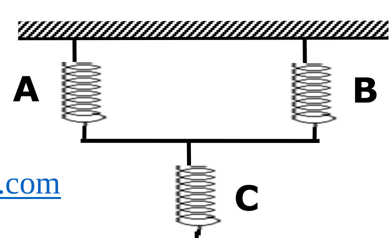
If the spring constant of each spring is **500N/m**, calculate the combined spring constant of the set-up. (3mk)

$K_e = k_p + k_1$

$1000 + 500$

$= 1500N/m$

12. Study the figure below and answer the question that follows.



 Copyright © 2020

The springs **A**, **B**, **C** and **D** are identical and each extends by **2cm**. When a force of **50N** is suspended from it. Determine the extension of the system. (3 mk)

$K = \frac{50}{0.02} = 2500N/m$

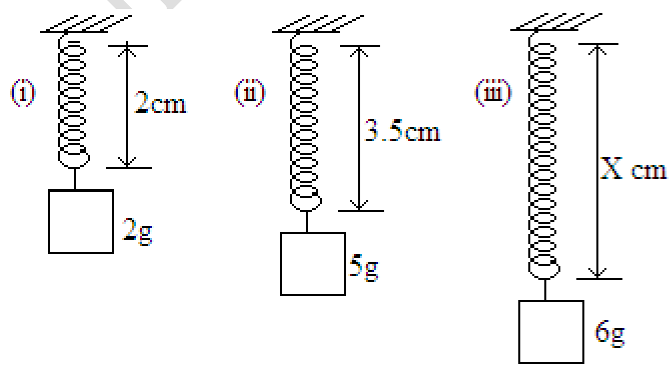
$E_{a,b} = \frac{50}{5000} = 0.01m$

$e_c = \frac{50}{2500} = 0.02m$

$e_d = 0.02m$

$e_T = 0.01+0.02+0.02=0.05m$

13. The diagram below shows three identical springs which obey Hooke's law.



Determine the length **X**. (3 mk)

$K = \frac{F}{e}$

$K = \frac{0.03}{0.015} = 2$ N/m

Copyright © 2020

$2 = \frac{0.04}{x - 0.02}$

2x – 0.04=0.04

2x = 0.08

$X = \frac{0.08}{2}$

X = 4cm

14. Figure shows a spiral spring fixed on a bench vertically. A mass of **0.5kg** is placed on top as shown in the figure below.

In **(a)** the height of the spring is **6cm** while in **(b)** the height is **4cm**. find the energy stored in the spring in figure **(b)**. (2mk

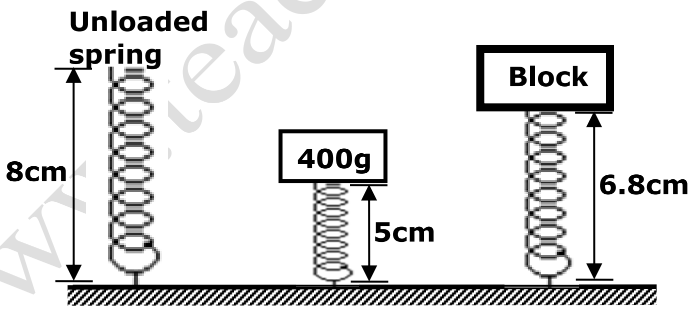
Energy stored = work done in compressing the spring

= ½ Fe^2

$= \frac{1}{2} \times 5 \times 0.0004$

= 0.001 J

15. The diagram below shows the same spring in three different situations; when unloaded, when supporting a load of **400g** and when supporting a wooden block. Find the mass of the wooden block. (3mk)



$K = \frac{F}{e}$

$= \frac{4}{0.03}$

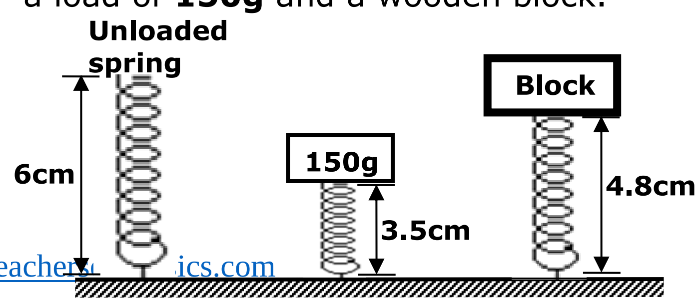
= 133.33 N/m

$133.33 = \frac{F}{0.012}$

F = 1.6 N

mass= 0.16 Kg

16. The diagram in figure below shows unloaded spring, when supporting a load of **150g** and a wooden block.



Copyright © 2020

Find the mass of the wooden block. (3mks)

$K = \frac{F}{e}$ $\quad = 60$ N/m $\quad F = 0.72$ N

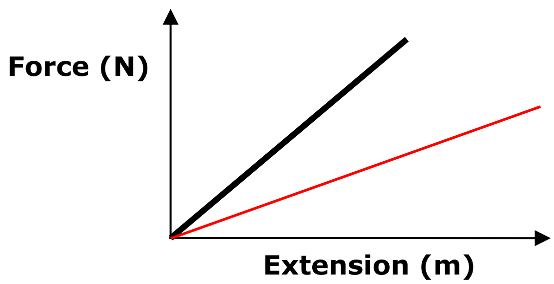
$= \frac{1.5}{0.025}$ $\quad 60 = \frac{F}{0.012}$ $\quad$ mass= 0.072 Kg

www.teachersofphysics.com

GRAPH SKETCHES

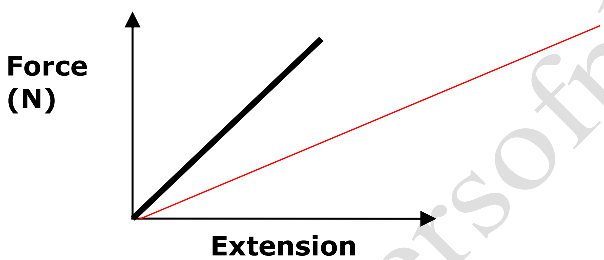
1. Figure below shows the variation of force with extension for a certain spring.

Copyright © 2020



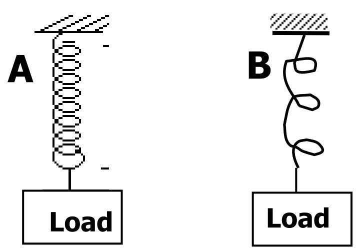
On the same axis, **sketch** the variation of force with extension for another similar spring whose length is double the first spring
(1mk)

2. Figure shows the variation force against extension for a spring obeying Hooke's law

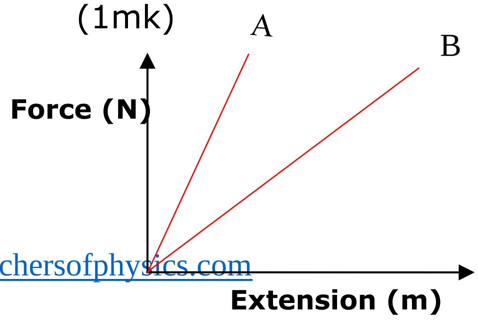


Sketch the same axes the variation of force against extension when two such springs are connected end to end.
(1mk)

3. The figure below shows two springs **A** and **B** made of same material, same diameter and same length but with different number of turns.



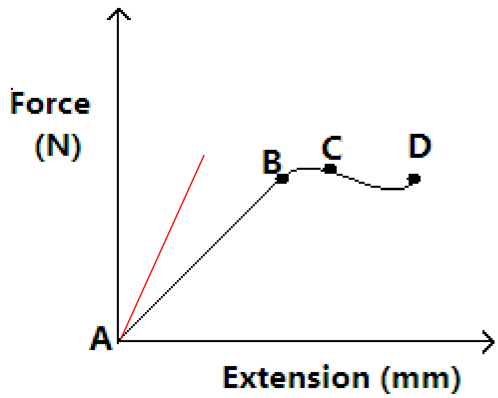
On the axis below sketch a graph of load against extension for each. (*Hooke's law is obeyed*)
(1mk)



www.teachersofphysics.com

Copyright © 2020

4. The graph in the figure below was obtained when suitable weights were suspended from a spiral spring and extensions measured



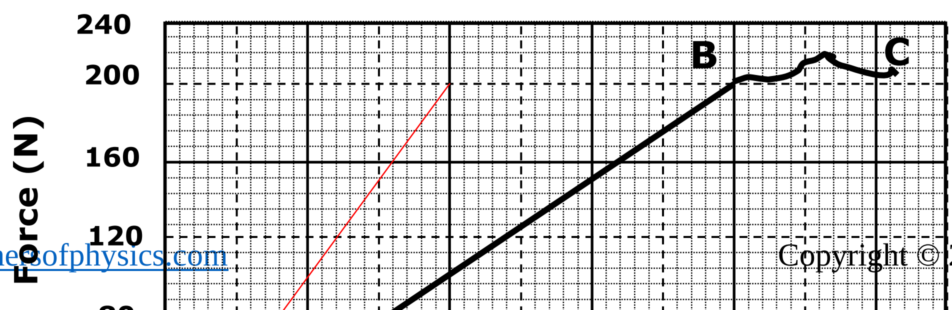
(a) Explain the shape of the graph between

(i) **AB** the spring obeys hooks law the spring undergoes elastic deformation

(ii) **CD** hooks law is no longer obeyed. The spring has exceeded yield point.

(b) Two identical spiral springs are then arranged in parallel and the weights suspended. On the same axes above, sketch the graph that would now be obtained. (2mks)

5. The graph in the figure below was obtained when suitable weights were suspended from a spiral spring and extensions measured .



www.teachersofphysics.com

 Copyright © 2020

(a) Explain the shape of the graph between

(iii) **AB**

Along AB the spring (or elastic material) is said to undergo elastic deformation. Hooks law is obeyed (1mk)

(iv) **BC**

The spring undergoes elastic deformation. Hooks law is no longer obeyed (1mk)

From the graph:

(b) Determine the elastic constant of the spring used. (3mk)

K $=\frac{\Delta F}{\Delta e} = \frac{200}{8}$ = 25 N/cm

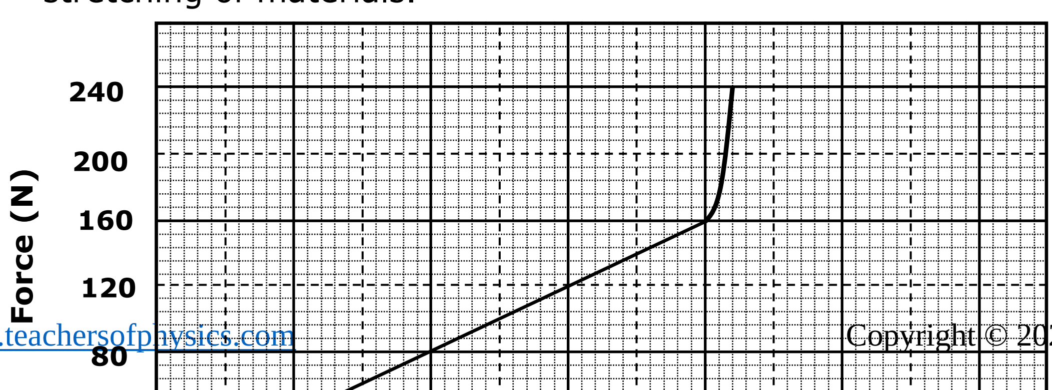
(c) What is the elastic limit of the material? (1mk

Elastic limit = 8.2 cm

(d) Sketch on the same axis the graph of force against extension when two such springs are connected in parallel. (1mk)

www.teachersofphysics.com

6. The graph below was obtained in an experiment to investigate the stretching of materials.



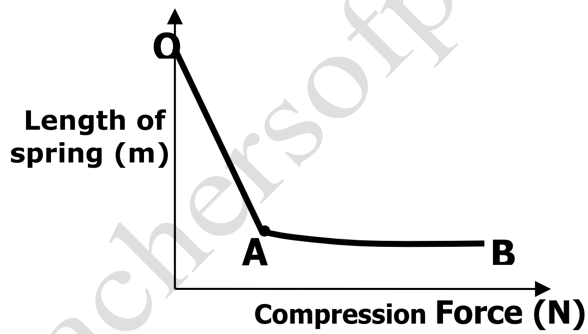
(i) Determine the constant of the spring used. (2mk)

K $= \frac{\Delta F}{\Delta e} = \frac{160}{8}$ = 20 N/m

(iii) Determine the elastic limit of the material. (1mk)

Elastic limit = 8m

7. Use the graph below showing the variation of the length of a spring and the compressional force applied on it to answer questions 3 and 4.



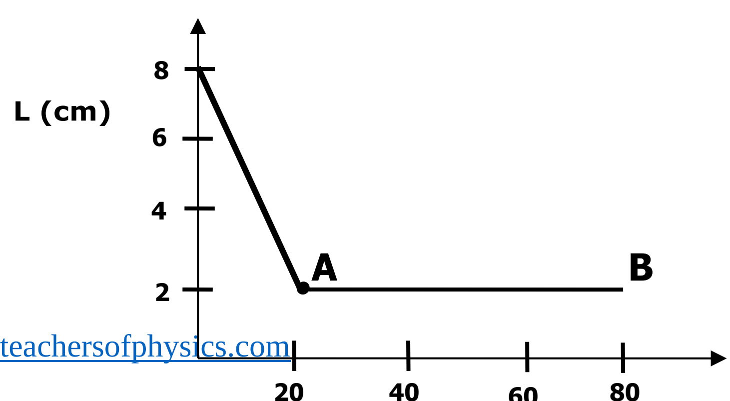
(i) **State** the significance of the point labelled **A**. (1mk)

It's the point that marks the yield point of the spring.

(ii) **Explain** the nature of the graph between **A** and **B**. (1mk)

The spring has undergone plastic deformation

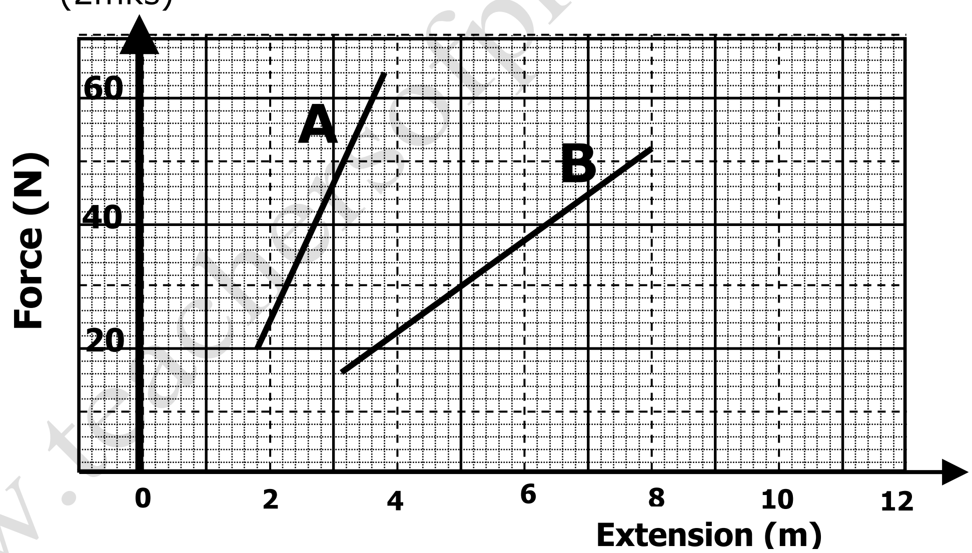
8. An experiment was performed to find out how the length **L** of a spiral spring varies with the compression force**, F** The figure shows the variation.



Copyright © 2020

(i) Draw a diagram of a possible set up of the apparatus
(ii) Over which range of the force does the spring obey Hooke's law? Up to 20N
(iii) Suggest a reason for the shape of the graph between **20N** and **80N.** The spring has undergone plastic deformation

9. The graph (curve) below show the variation of force against extension (cm) of two spiral springs of same material , same wire thickness, length but of different diameters (one large and the other small).Identify which graph **(A** or **B**) represents which spring. (2mks)



✓ **A** large spring while **B** the other small

TABLES

In this section teacher to follow through the student's work
Award; A $\longrightarrow$ 1—correctly labeled axis with units
S $\longrightarrow$ 1 --- uniform, simple, accommodative scale
P $\longrightarrow$ 2 --- $\frac{3}{4}$ of correctly plotted points within one small square.

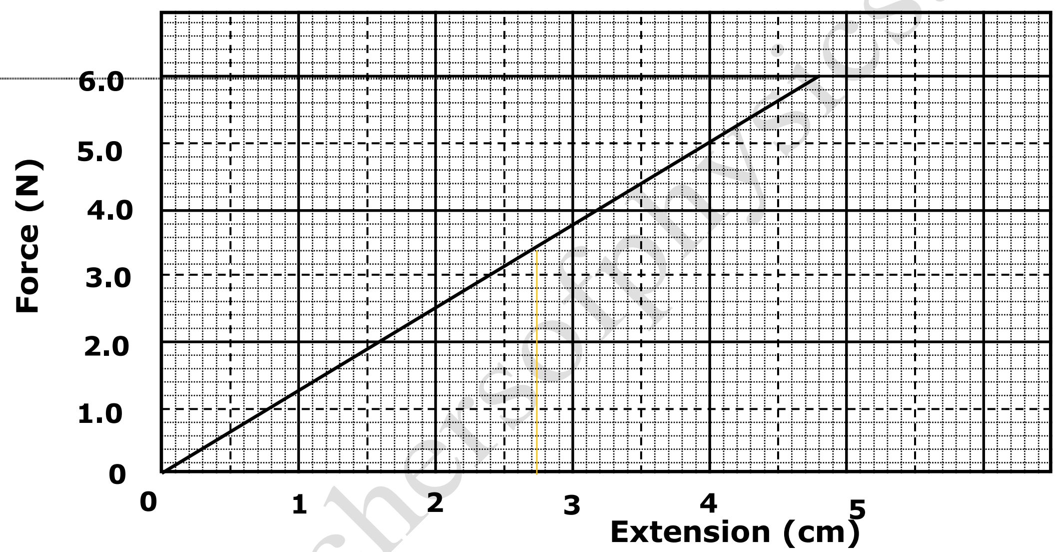
Copyright © 2020

L/C → 1---- L—awarded if the line (drawn using a ruler) passes through ¾ of the correctly plotted points.
C smooth curve (free hand drawn). Through all the points.
Remember no line no slope

1. The table below shows the value of extensions of a spiral spring when various forces are applied.

Force F(N)	0	1.0	2.0	3.0	4.0	5.0	6.0
Extension e(cm)	0	0.8	1.6	2.4	3.2	4.0	4.8

a) Plot a graph of force (y – axis) against the extension. (5mk)



b) Determine the work done in stretching the spring by **2.7cm**; using the graph. (2mk)

W.d = ½ ke^2

K= $\frac{\Delta F}{\Delta e} = \frac{4}{0.032}$ = 125 N/m

Wd $= \frac{1}{2} \times 125 \times 0.027 \times 0.027$

=0.046J

c) Determine the spring constant of the spring. Give your answer in **SI** units. (2mk)

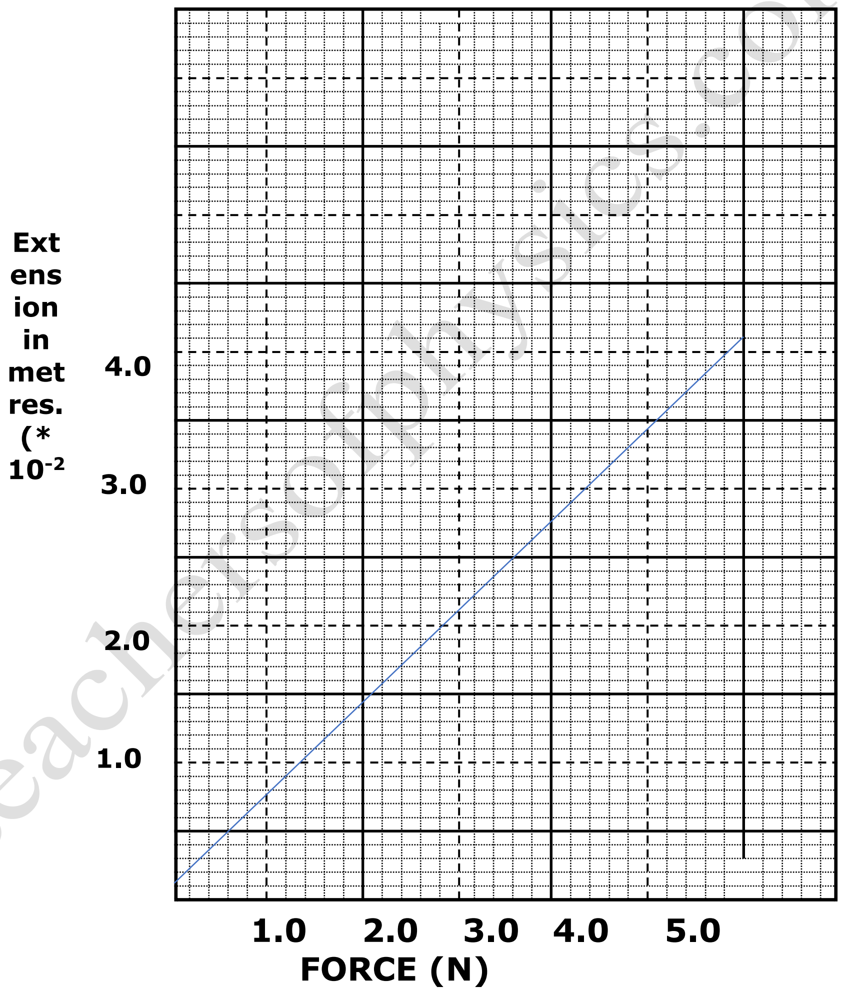
Ans → working on b) above spring constant = 125 N/m

 Copyright © 2020

2. The table below shows the values of extensions of a spiral spring when various forces were applied on it.

Force, F (N)	**0.0**	**1.2**	**2.0**	**3.6**	**4.0**	**4.8**	**6.0**
Extension, e (cm)	**0.0**	**0.8**	**1.3**	**2.5**	**2.7**	**3.2**	**4.0**
Extension (e) (m)	0.0	0.008	0.013	0.025	0.027	0.032	0.040

i) Plot a graph of extension in metres (y-axis) against force (x-axis). (5mks) (ASPL)



www.teachersofphysics.com

Use the graph to determine the spring constant of the spring.

(2mks $\frac{1}{slope\ of\ the\ graph}$

$=\Delta e/\Delta F$

$=\frac{0.04}{6.0}=0.0067$

$k=\frac{1}{0.0067}=150N/m$

(ii) Determine the work done in stretching the spring by **4.5cm**.
(2mks) Wd = ½ x slope x e^2

$=\frac{1}{2}\times 150 \times (0.045)^2$

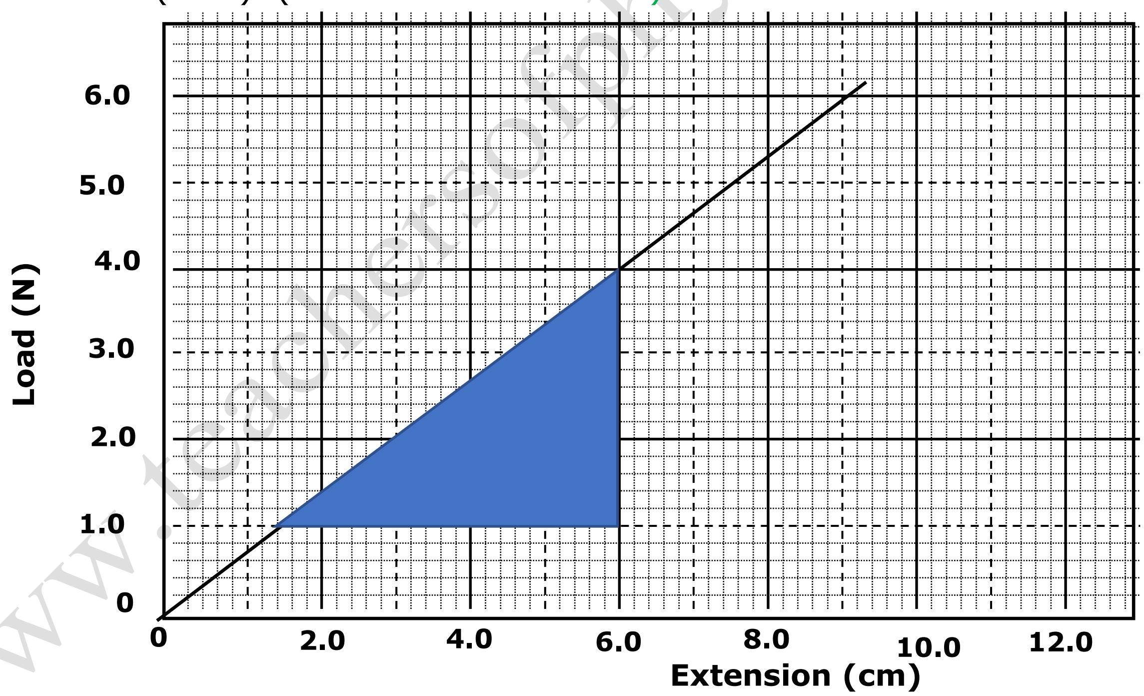
$=0.1519$ J

3. The following results were obtained in an experiment to verify Hooke's law when a spring was extended by hanging various loads on it.

Load, L(N)	0.00	1.00	2.00	3.00	4.00	5.00	6.00
Length of spring (cm)	**10.00**	**11.50**	**13.00**	**14.50**	**16.00**	**18.50**	**24.00**
Extension, e (cm)	**0.00**	**1.50**	**3.00**	**4.50**	**6.00**	**8.50**	**14.00**

i) Complete the table for extension, e, above (1mk)

ii) Plot a graph of Load (y-axis) against extension. (5mk) (this is a line of best fit)



ii) From the graph, determine the spring constant, k.(3 mk) *(correct evaluated slope from the graph)*

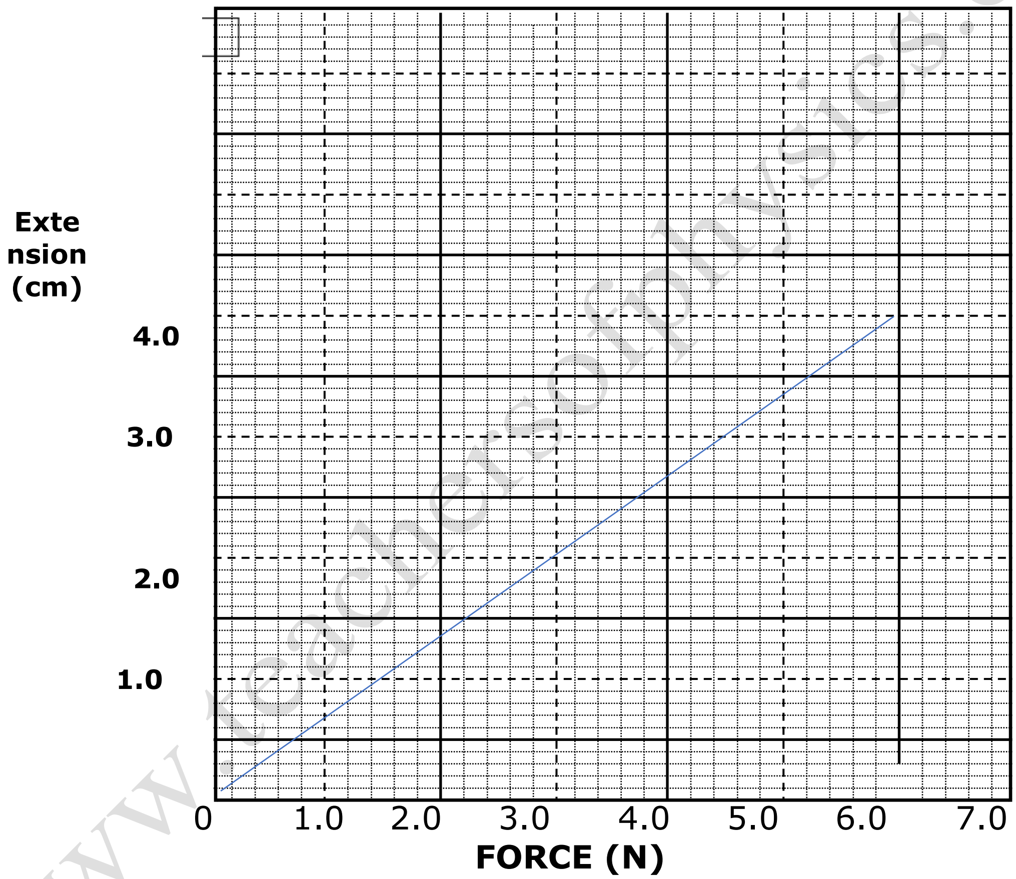
$\frac{4.0-1.0}{6.0-1.5} = \frac{4}{0.045}$

$=88.89N/m$

4. A student carried out an experiment to investigate the relationship between the force and extension produced on a spiral spring. He tabulated his results as shown below.

Force (N)	0	0.8	1.5	3.0	4.5	6.0	7.5
Extension (cm)	0	0.50	1.0	2.0	3.0	4.0	5.0

(i) Plot a graph of extension in cm in the y-axis against force in N (5 mk) *(ASPL)*



(ii) Determine the spring constant. (3 mks)

(correct evaluated slope from the graph)

K= 1/slope

Slope= $\frac{4-2}{6-3}$=0.667

K= $\frac{1}{0.667}$ =1.5 N/cm

(iii) What force would be required to produce an extension of 2.5cm (1 mk) correct read from the drawn graph

3.7N

(iv) What extension is produced by:

(a) A force of **5.5N** (1 mk)

3.8cm

correct read from the drawn graph

(b) A mass of **700g** (1 mk)

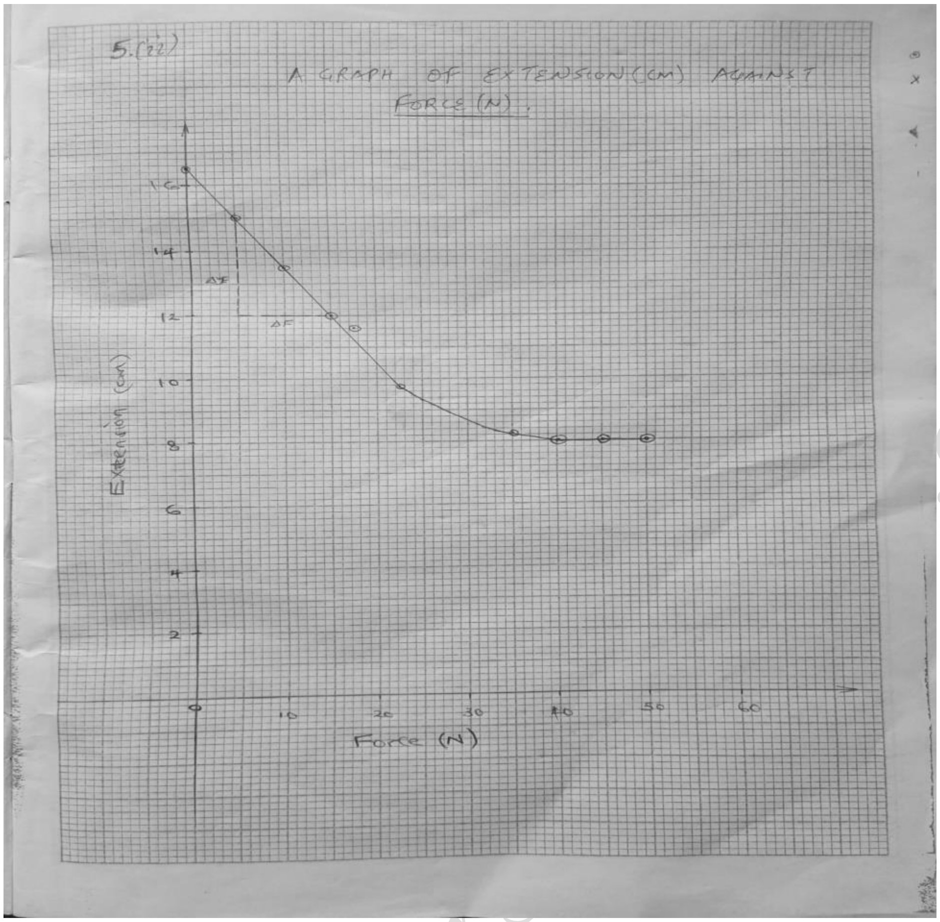
5. The table below has a data recorded for a compressional force on a spring balance.

Force F (N)	**0**	**5.0**	**10**	**15**	**17.5**	**22.5**	**35.0**	**40**	**4**	**50**
Length of spring L (cm)	**16.5**	**15.0**	**13.5**	**12**	**11.6**	**9.75**	**8.25**	**8**	**8**	**8**
Compression of spring e (cm)	**0**	**0.5**	**3**	**4.5**	**4.9**	**6.75**	**8.25**	**8.5**	**8.5**	**8.5**

i) Complete the table for the values of compression **(e)** (2mk)

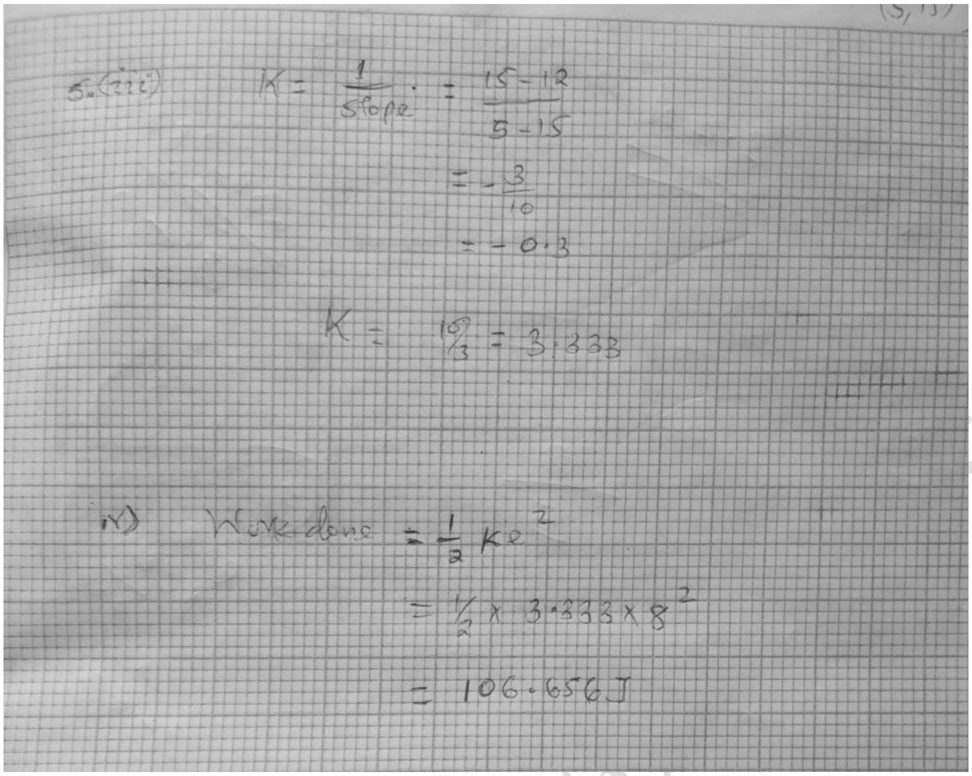
ii) Plot a graph of extension (vertical axis) versus force applied on the spring (horizontal axis). (5mk) (ASPL)

www.teachersofphysics.com



From your graph determine.

iii) The spring constant **K**. (Correct evaluated slope from the graph. (2mk)



iii) Work done in compressing the spring until the coils just come into contact. (2mks)

Wd = ½ x slope x e^2

6. A spring with its upper end fixed, hang vertically and several masses are suspended from its lower end one at a time. The readings were recorded as shown.

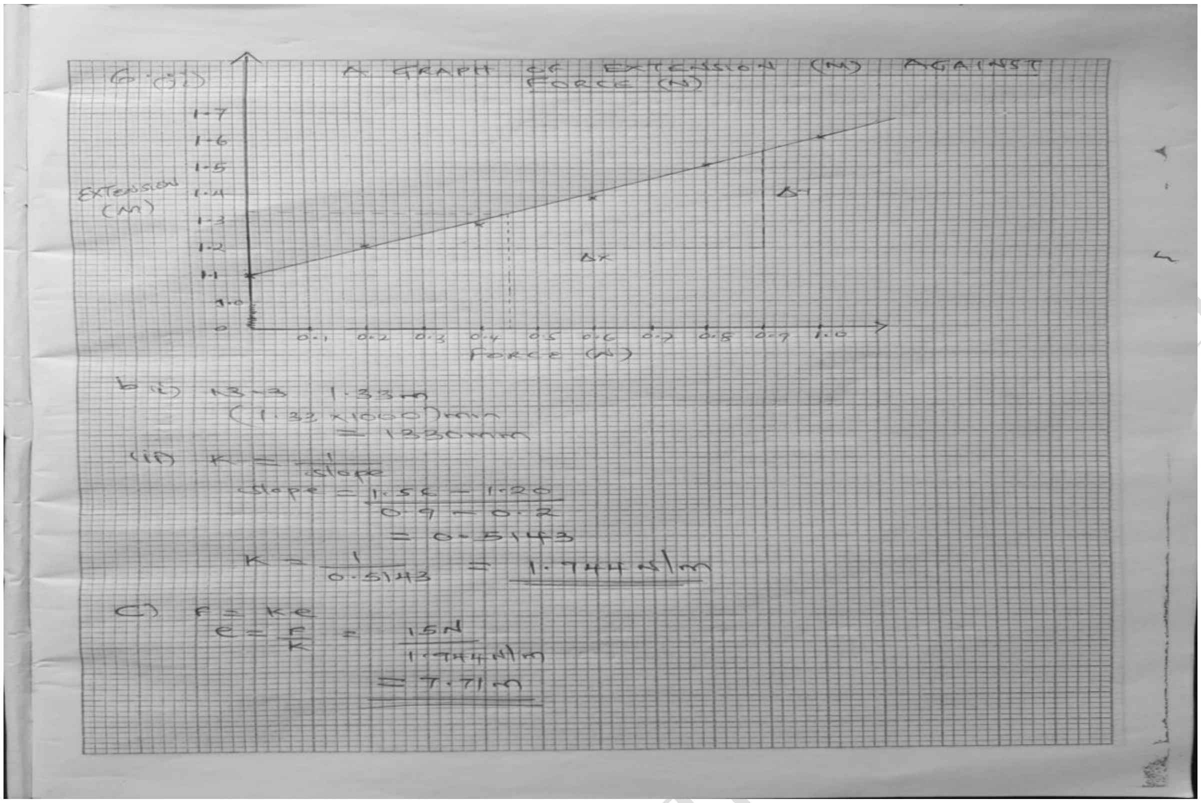
Mass in kg	**0**	**0.02**	**0.04**	**0.06**	**0.08**	**0.10**
Extension (mm)	**110**	**121**	**129**	**139**	**151**	**161**
Force N	**0**	**0.2**	**0.4**	**0.6**	**0.8**	**1**
Extension in m	**1.1**	**1.21**	**1.29**	**1.39**	**1.51**	**1.61**

i) Fill in the table (1mk

ii) Plot a graph of extension in (m) against force in N. (5mk) (ASPL)

www.teachersofphysics.com

 Copyright © 2020



b) **(i)** From the graph determine the extension of a mass **0.045kg**. Give your
answer in ***mm*** **(read from the graph)** (2mk)

(ii) Determine the spring constant of the spring (2 mk)
(slope)

d) If two such springs were connected in series what extension would they show when a mass of **1.5kg** hangs from one end? **(3mks**)

www.teachersofphysics.com

 Copyright © 2020