PHYSICS

BOOKS - CENGAGE PHYSICS

ELASTICITY

Worked Examples

1. Two wires of the same material of same length have area of cross sections in the ratio $1:2$ If forces are applied in the ratio $2:1$ to

extend them what be the ratio of their extension in length ?

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2. A steel wire has diameter 2 mm and its maximum permitted strain is 0.001. If the Young's modulus of steel is $20 \times 10^{10} \mathrm{N\ m}^{-2}$, find the maximum load the wire can withstand.

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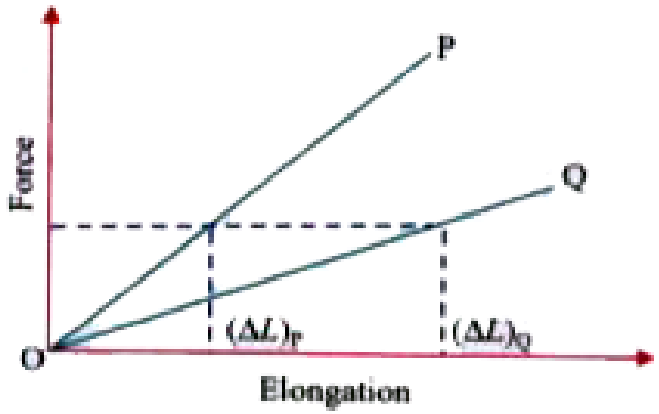
3. The graph in Fig. 11.8 shows the variation of elongation with tensile force for two wires P and Q.



If P and Q are of the same material and have the same length, which one has a greater area of cross section ?

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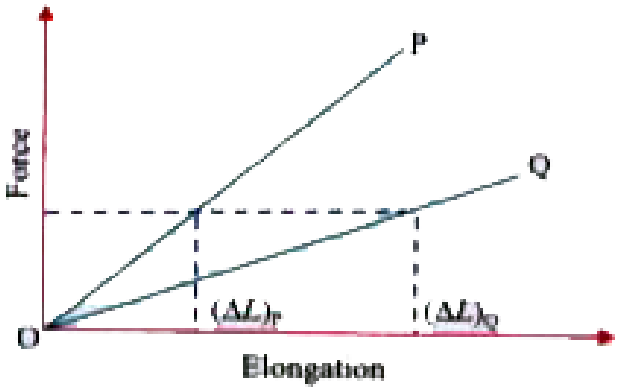
4. The graph in Fig. shows the variation of elongation with tensile force for two wires P and Q.



If P and Q are identical wires of different materials, which one is more elastic ?

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Mandatory Exercise Exercise Set I

1. Why are the bridges declared unsafe after long use ?

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2. Why does a wire get heated when it is bent back and forth ?

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3. Arrange the following in the increasing order of elasticity : Steel, Copper, Rubber, and Diamond.

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4. Water is more elastic than air, why ?

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5. Steel is

A. less elastic than rubber

B. more elastic than rubber

C. as elastic as rubber

D. more plastic than rubber

Answer: B

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6. Of the following, the most elastic material is

A. iron

B. rubber

C. diamond

D. copper

Answer: C

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Mandatory Exercise Exercise Set Ii

1. If the length of a wire is doubled, does its Young's modulus change ? Explain.

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2. Equal loads are suspended using identical wires of steel and copper. Which wire is elongated more ?

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3. Young's modulus of a perfectly rigid body is

A. zero

B. unity

C. finite and low

D. infinite

Answer: D

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4. The length L and diameter d of four wires of the same material are given below. Which of these will elongate the most, when the same tension is applied ?

A. L=50 cm, d=0.5 mm

B. L=100 cm, d=1.0 mm

C. L=200 cm, d=2.0 mm

D. L=300 cm, L=3.0 mm

Answer: A

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5. A force of 20 N applied to the ends of a wire 4-m long produces an extension of 0.24 mm. If

the diameter of the wire is 2 mm, find the Young's modulus of its material.

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6. A steel wire has a diameter of 1.6 mm and a length 6 m. What force must be applied to produce an extension of 2 mm ? Given, $E = 2 \times 10^{11} \ \mathrm{N\ m^{-2}}$ for steel.

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7. A copper wire has a length of 4 m and a diameter of 3 mm. Find the extension produced in it by a force of 30 N. Given, $E = 1.1 \times 10^{11} \mathrm{N\ m^{-2}}$ for copper.

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8. For a typical material the strain - stress graph is given below :

Find the Young's modulus and the breaking stress.

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9. Compute the elongation of the steel wire in the figure. Unloaded length of the steel wire $= 1.5$ m, the diameter of the wire is 0.25 m, Young's modulus of steel is 2×10^{11} $\mathrm{N\ m^{-2}}$.

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Mandatory Exercise Exercise Set Ii Multiple Choice Questions With One Correct Answer

1. The length of an iron wire is L and area of cross - section is A. The increase of length l is observed on applying the force F on its two ends. Which of the following statement is correct ?

A. Increase in length is inversely proportional to L

B. Increase in length is proportional to area

C. Increase in length is inversely proportional to area

D. Increase in length is proportion to Young's modulus

Answer: C

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2. The ratio of the lengths of two wires A and B of same material is $1:2$ and the ratio of their diameter is $2:1$. They are stretched by the same force, then the ratio of increase in length will be

A. $2:1$

B. $1:4$

C. $1:8$

D. $8:1$

Answer: C

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3. A force F is needed to break a copper wire having radius R. the force needed to break a copper wire of radius 2R will be

A. $\frac{F}{2}$

B. 2F

C. 4F

D. $\frac{F}{4}$

Answer: C

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4. The Young's modulus of a wire of length L and radius r is Y. If the length and radius is reduced to L/2 and r/2 respectively, then its Young' modulus will be

A. $Y/2$

B. Y

C. 2Y

D. 4Y

Answer: B

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5. A and B are two wires. The radius of A is twice that of B. They are stretched by the same load. Then what is the stress on B ?

A. Equal to that on A

B. Four times that on A

C. Two times that on A

D. Half that on A

Answer: B

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6. When a certain weight is suspended from a long uniform wire, its length increases by 1 cm. If the same weight is suspended from the other wire of the same material and length but having a diameter half of the first one then the increase in length will be

A. 0.5 cm

B. 2 cm

C. 4 cm

D. 8 cm

Answer: C

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7. Hook's law defines

A. stress

B. strain

C. modulus of elasticity

D. elastic limit

Answer: C

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8. A wire is loaded by 6 kg at its one end, the increase in length is 12 mm. If the radius of the wire is doubled and all other magnitudes are unchanged, then increase in length will be

A. 6 mm

B. 3 mm

C. 24 mm

D. 48 mm

Answer: B

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9. If Young's modulus of iron is $2 \times 10'' \ \mathrm{N/m^2}$ and the interatomic spacing

between two molecules is 3×10^{-10} m the interatomic force constant is

A. 60 N/m

B. 120 N/m

C. 30 N/m

D. 180 N/m

Answer: A

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10. If the temperature increases, the modulus of elasticity

A. decreases

B. increases

C. remains constant

D. becomes zero

Answer: A

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11. The diameter of a brass rod is 4 mm and Young's modulus of brass is $9 \times 10^{10}\ \mathrm{N/m^2}$. The force required to stretch by $0.1\,\%$ of its length

A. $360\pi N$

B. 36 N

C. $144\pi \times 10^3 N$

D. $36\pi \times 10^5 N$

Answer: A

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12. In a wire of length L, the increase in its length is ΔL. If the length is reduced to half, then the increase in its length will be

A. ΔL

B. $2\Delta L$

C. $\frac{\Delta L}{2}$

D. none

Answer: C

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13. If the length of a wire is reduced to half, then it can hold the

A. half load

B. same load

C. double load

D. one fourth load

Answer: B

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14. To double the length of an iron wire having area of $0.5 \ \text{cm}^2$ cross section, the required force will be [Given $\left(Y = 10^{12} \ \text{dyne/cm}^2\right)$]

A. $10 \times 10^{-7} N$

B. $10 \times 10^{7} N$

C. $0.5 \times 10^{-7} N$

D. $0.5 \times 10^{12} N$

Answer: D

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15. The spring balance does not read properly after its long use because

A. elasticity of spring increases

B. elasticity of spring decreases

C. plastic power decreases

D. plastic power increases

Answer: B

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16. Why springs are made up of steels and not copper commonly ?

A. Copper is costlier than steel

B. Copper is more elastic than steel

C. Steel is more elastic than copper

D. None of the above

Answer: C

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17. Two wires of copper having the length in the ratio $4:1$ and their radii ratio as $1:4$ are stretched by the same force. The ratio of longitudinal strain in the two will be

A. $1:16$

B. $16:1$

C. $1:64$

D. $64:1$

Answer: B

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18. If a load of 9 kg is suspended on a wire, the increase in length is 4.5 mm. the force constant of the wire is

A. $0.49 \times 10^4 \ \mathrm{N/m}$

B. $1.96 \times 10^4 \ \mathrm{N/m}$

C. $4.9 \times 10^4 \ \mathrm{N/m}$

D. $0.196 \times 10^4 \ \mathrm{N/m}$

Answer: B

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19. The diameters of two wires of same material is $n:1$. The length of wires is 4 m each. On applying the same load, the increase in length of this wire will be

A. n^2 times

B. n times

C. 2n times

D. none

Answer: A

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20. Longitudinal stress of $1kg/mm^2$ is applied on a wire. The percentage increase in length is $(Y = 10^{11}N/m^2)$

A. 0.002

B. 0.001

C. 0.003

D. 0.001

Answer: B

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21. A steel wire is stretched with a definite load. If the Young's modulus of the wire is Y. For decreasing the value of Y.

A. radius should be increased

B. radius should be decreased

C. length should be increased

D. none

Answer: D

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Consolidated Exercise

1. Comprehension

Vulcanized rubber shows a distinctly different stress - strain relation as shown in the figure. The material remains elastic even when it is stretched to over several times its original length. In the case shown in the graph, the

length is increased to 8 times its natural length, even then if the stretching forces are removed, it will come back to its original length.

In which part of this large deformation is the stress portinal to strain ?

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2. Comprehension

Vulcanized rubber shows a distinctly different

stress - strain relation as shown in the figure. The material remains elastic even when it is stretched to over several times its original length. In the case shown in the graph, the length is increased to 8 times its natural length, even then if the stretching forces are removed, it will come back to its original length.

When the deforming force is removed, the original curve is not retraced although the sample finally acquires its natural length.

What does it imply about the work done by the material ?

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3. Comprehension

Vulcanized rubber shows a distinctly different stress - strain relation as shown in the figure. The material remains elastic even when it is stretched to over several times its original length. In the case shown in the graph, the length is increased to 8 times its natural

length, even then if the stretching forces are removed, it will come back to its original length.

What will happen to energy absorbed by the material as it regains its original configuration ?

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4. Comprehension

Vulcanized rubber shows a distinctly different

stress - strain relation as shown in the figure. The material remains elastic even when it is stretched to over several times its original length. In the case shown in the graph, the length is increased to 8 times its natural length, even then if the stretching forces are removed, it will come back to its original length.

How does elastic hysteresis find its application in shock absorbers ?

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5. Match the following :

Column A		Column B
(1) Elasticity	(a)	$\frac{\text{breaking strees}}{\text{working stress}}$
(2) Plasticity	(b)	regaining original configuration
(3) Rigidity	(c)	permanent deformation
(4) Stress	(d)	no deformation
(5) Strain	(e)	fractional change in dimensions
(6) Hooke's law	(f)	stress $\propto$ strain
(7) Young's modulus	(g)	internal resistance to deforming force
(8) Factor of safety	(h)	elasticity in length

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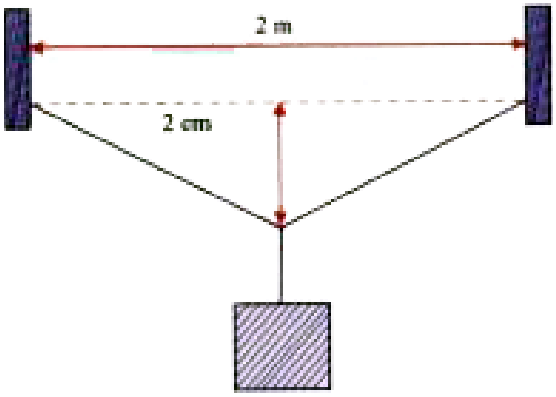
Challenging Exercise

1. A wire of length 2 m is fixed, as shown. When a load is suspended from the center, it sags by 2 cm. Find the strain.



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2. Calculate the percentage increase in length of a wire of diameter 2.2 mm stretched by a load of 100 kg. Young's modulus of wire is $12.5 \times 10^{10} \ \mathrm{N\,m^{-2}}$.

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3. Find the maximum length of steel wire that can hang without breaking. Breaking stress $= 7.9 \times 10^{12} \ \mathrm{dyne\,cm^{-2}}$. Density of steel $= 7.9 \ \mathrm{g/cc}$.

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4. Two wires of the same material have lengths in the ratio $1:2$ and diameters in the ratio $2:1$. If they are stretched by the same force, the ratio of their expansion will be

A. $1:8$

B. $8:1$

C. $4:1$

D. $1:4$

Answer:

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5. One end of uniform wire of length L and of weight W is attached rigidly to a point in the roof and a weight W_1 is suspended from its lower end. If s is the area of cross section of the wire, the stress in the wire at a height ($3L/4$) from its lower end is

A. $\frac{W_1 + W/4}{A}$

B. $\frac{W_1}{A}$

C. $\frac{W_1 + (3W/4)}{A}$

D. $\frac{W_1 + W}{A}$

Answer: C

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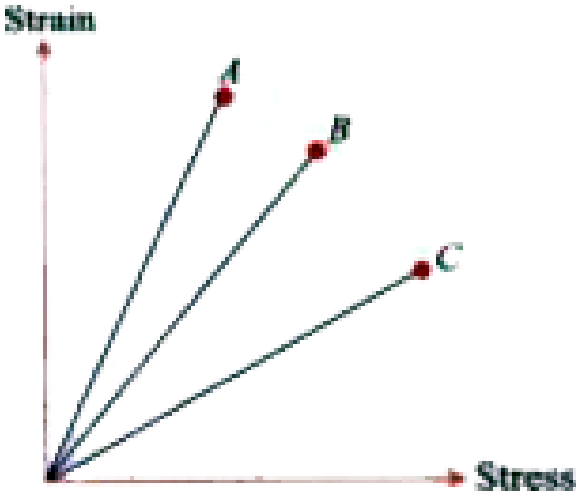
6. Stress - strain graph of three different are as shown. A,B and C are the Young's modulus of the wires. Which of the following statement is

correct ?



A. Y of wire a is maximum

B. Y of wire B is maximum

C. Tensile strength of C is maximum

D. None of the above

Answer: D

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7. For four wires made of the same material, and same length the load v/s extension graph is as shown. The thickest wire is represented by the line

A. OP

B. OQ

C. OR

D. OS

Answer: A

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8. As shown in the diagram three blocks of same mass m are connected with ropes A and B of same cross - sectional area a and Young's modulus Y. If the surfaces are smooth, calculate the strain developed in wire B.

A. $\frac{3mg}{3aY}$

B. $\frac{2mg}{3aY}$

C. $\frac{mg}{aY}$

D. $\frac{3mg}{aY}$

Answer: B

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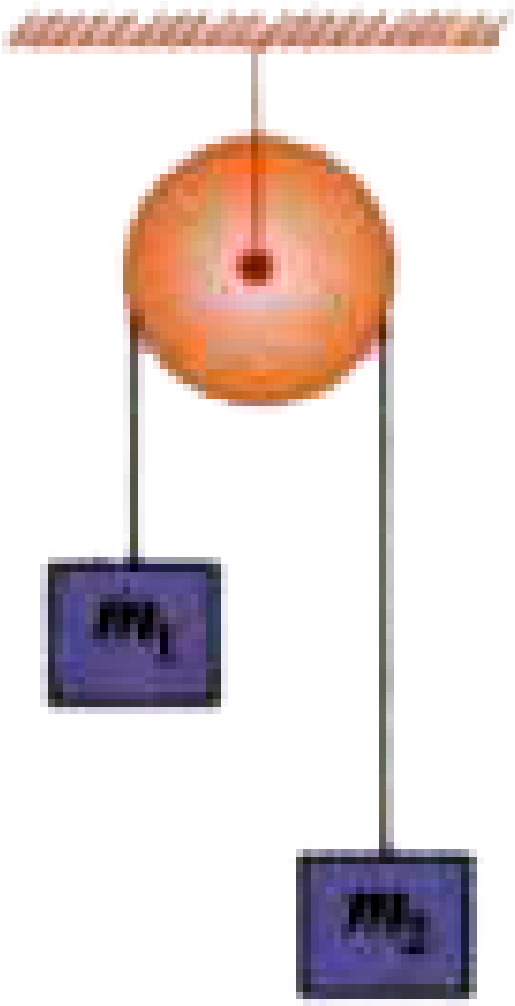
9. Two blocks of masses m_1 and m_2 are hanging from a pulley with the help of a ropw of Young's modulus Y as shown in the

diagram. The length of the wire is L and area of cross section is A. When system is released from rest, the elongation in the length of wire

is.



A. $\frac{m_1 m_2 g L}{(m_1 + m_2 A Y)}$

B. $\frac{m_1 m_2 g L}{2(m_1 + m_2) A Y}$

C. $\frac{2 m_1 m_2 g L}{(m_1 + m_2) A Y}$

D. $\frac{m_2 g L}{(m_1 + m_2) A Y}$

Answer: C

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10. A horizontal rod suspended from two wires of same length and cross - section. Their Young's modulus are Y_1 and Y_2 respectively.

The equivalent Young's modulus will be

A. $\frac{Y_1 + Y_2}{2}$

B. $Y_1 + Y_2$

C. $2(Y_1 + Y_2)$

D. $(Y_1 + Y_2)$

Answer: A

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Olympiad And Ntse Level Exercises

1. A steel rod of length 1m and radius 10 mm is stretched by a force 100 KN along its length. The stress produced in the rod $Y_{\text{Steel}} = 2 \times 10^{11} \ \text{N m}^{-2}$

A. $3.18 \times 10^{6} \ \text{N m}^{-2}$

B. $3.18 \times 10^{7} \ \text{N m}^{-2}$

C. $3.18 \times 10^{8} \ \text{N m}^{-2}$

D. $3.18 \times 10^9 \ \ \mathrm{N\,m^{-2}}$

Answer: C

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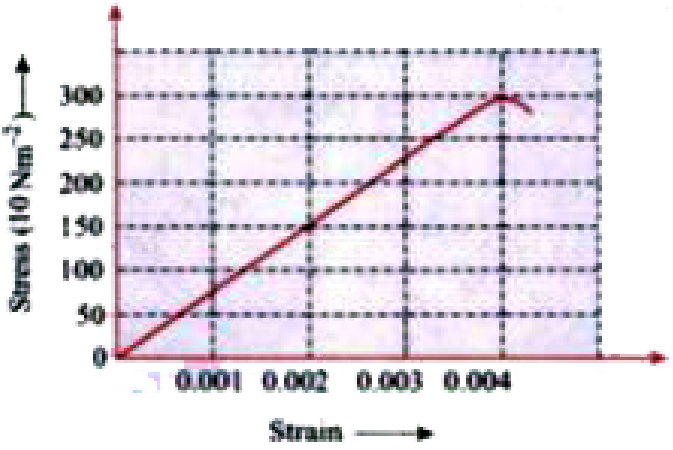
2. Figure shows the strain - stress curve for a given material. The Young's modulus of the

material is



A. $5 \times 10^{9} \quad \mathrm{N\ m^{-2}}$

B. $5 \times 10^{10} \mathrm{N\ m^{-2}}$

C. $7.5 \times 10^{9} \quad \mathrm{N\ m^{-2}}$

D. $7.5 \times 10^{10} \quad \mathrm{N\ m^{-2}}$

Answer: D

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3. Three wires a, B and C are of the same length and cross section. They are each stretched by applying the same force to the ends. The wire A is stretched least and comes back to its original length when the stretching force is removed. The wire B is stretched more than A and also comes back to its original length when the stretching force is removed. The wire C is stretched most and remains stretched even when stretching force is

removed. the greatest Young's modulus of elasticity is possessed by the material of wire

A. A

B. B

C. C

D. Date is not sufficient

Answer: A

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4. A wire of length L and density ρ and Young's modulus Y is hanging from a support. Find the elongation in the length of wire at which wire will break:

A. $\frac{L^2\rho g}{Y}$

B. $\frac{L^2\rho g}{2Y}$

C. $\frac{2L^2\rho g}{Y}$

D. $\frac{L^2\rho g}{4Y}$

Answer: A

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5. A 900 kg elevator hangs by a steel cable for which the allowable stress is $1.15 \times 10^8 \ \mathrm{N/m^2}$. What is the minimum diameter required if the elevator accelerates upward at $1.5 \ \mathrm{m/s^2}$? Take $g = 10 \ \mathrm{m/s^2}$.

A. $\dfrac{6 \times 10^{-2}}{\sqrt{5\pi}} m$

B. $\dfrac{6 \times 10^{-2}}{\sqrt{10\pi}} m$

C. $\dfrac{3 \times 10^{-2}}{\sqrt{10\pi}} m$

D. $\dfrac{3 \times 10^{-2}}{\sqrt{5\pi}} m$

Answer: B

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6. The following four wires are made of the same material which of these will have the largest extension when the same tension is applied

A. length 50 cm and diameter 0.5 mm

B. length 100 cm and diameter 1 mm

C. length 200 cm and diameter 2 mm

D. length 300 cm and diameter 3 mm

Answer: A

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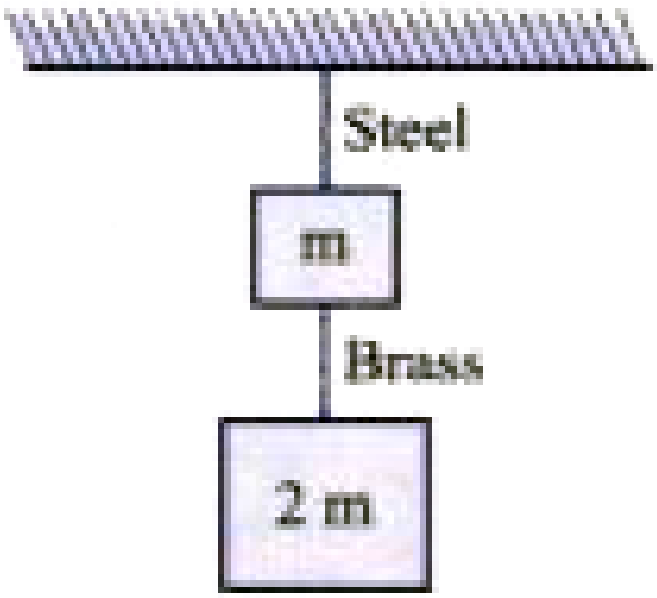
7. If the ratio of lengths, radii and Young's moduli of steel and brass wires in the figure are a,b and c respectively, then the corresponding ratio of increase in their length

is



A. $\frac{2a^2c}{b}$

B. $\frac{3a}{2b^2c}$

C. $\frac{2ac}{b^2}$

D. $\frac{3c}{3ab^2}$

Answer: B

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8. A copper wire $\left(Y = 10^{11}\ \mathrm{Nm}^{-2}\right)$ of length 8 m and steel wire $\left(Y = 2 \times 10^{11}\ \mathrm{Nm}^{-2}\right)$ of length 4 m and each of cross - sectional area $0.5\ \mathrm{cm}^2$ are fastened end to end and stretched with a tension of 500 N. Match the given columns and select the correct option from the codes

given below.

A. i-r,ii-p,iii-q

B. i-p,ii-q,iii-r

C. i-q,ii-r,iii-s

D. i-p,ii-s,iii-p

Answer: A

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9. Read the given statements and select the correct option.

Assertion : The bridges are declared unsafe after a long use

Reason : Elastic strength of bridges loses with time.

A. If both assertion and reason are true and reason is the correct explanation of assertion.

B. If both assertion and reason are true but reason is not the correct explanation of assertion.

C. If assertion is true but reason is false.

D. If both assertion and reason is false.

Answer: A

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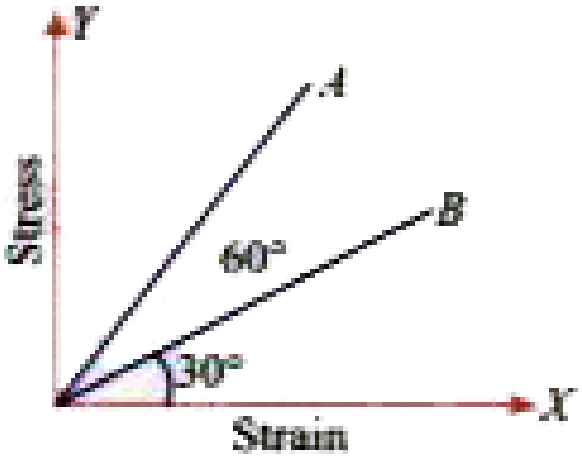
10. The stress versus strains graphs for wires of two materials A and B are as shown in the figure. If YA and YB are the Young's moduli of the materials, then



A. $Y_B = 2Y_A$

B. $Y_A = Y_B$

C. $Y_B = 3Y_A$

D. $Y_A = 3Y_B$

Answer: D

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