PHYSICS

BOOKS - MODERN PUBLICATION

Elasticity

Example

1. A wire increases by 10^{-3} of its length when a stress of $10^{8} Nm^{-2}$ is applied on it what is

the Young's modulus of the material of the wire?

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2. Find the bulk modulus of water from the following data : Initial volume = 500.0 litre, pressure increase-100.0 atm, final volume-497.5 litre.

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3. A cube of aluminium of each side 4 cm is subjected to a tangential (shearing) force. The top face of the cube is sheared through 0.012 cm with respect to the bottom Find shearing strain Given $\nu = 2.08 \times 10^{11}$ dyne cm^2

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4. A cube of aluminium of each side 4 cm is subjected to a tangential (shearing) force. The top face of the cube is sheared through 0.012

cm with respect to the bottom Find shearing stress and shearing force. Given $\nu = 2.08 \times 10^{11}$ dyne cm^2

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5. A steel wire of length 3.6 m and cross section $2.5 \times 10^{-5} m^2$ stretches by the same amount as a copper wire of length 2.4 m and cross-section $3.2 \times 10^{3} m^2$ under a given load. What is the ratio of the Young's modulus of steel to that of copper?

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6. If a compressive force of 3.0×10^4 N is exerted on the end of a 20 cm long bone of cross-sectional area $3.6cm^2$. will the bone break? Given, compressive strength of bone = $7.7 \times 10^8 Nm^2$ and Young's modulus of bone $1.5 \times 10^{10} Nm^2$

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7. If a compressive force of 3.0×10^4 N is exerted on the end of a 20 cm long bone of cross-sectional area $3.6cm^2$. if the bone do not break, by how much does it shorten ? Given, compressive strength of bone = $7.7 \times 10^8 Nm^2$ and Young's modulus of bone $1.5 \times 10^{10} Nm^2$

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8. A hollow cylindrical column of steel support a load of 16,000 kg. The inner and outer radii of the column are 40 cm and 50 cm respectively. Assuming the load distribution to be uniform, calculate the compressional strain of the column. Given that Young's modulus of steel = 2.0×10^{41} Pa.

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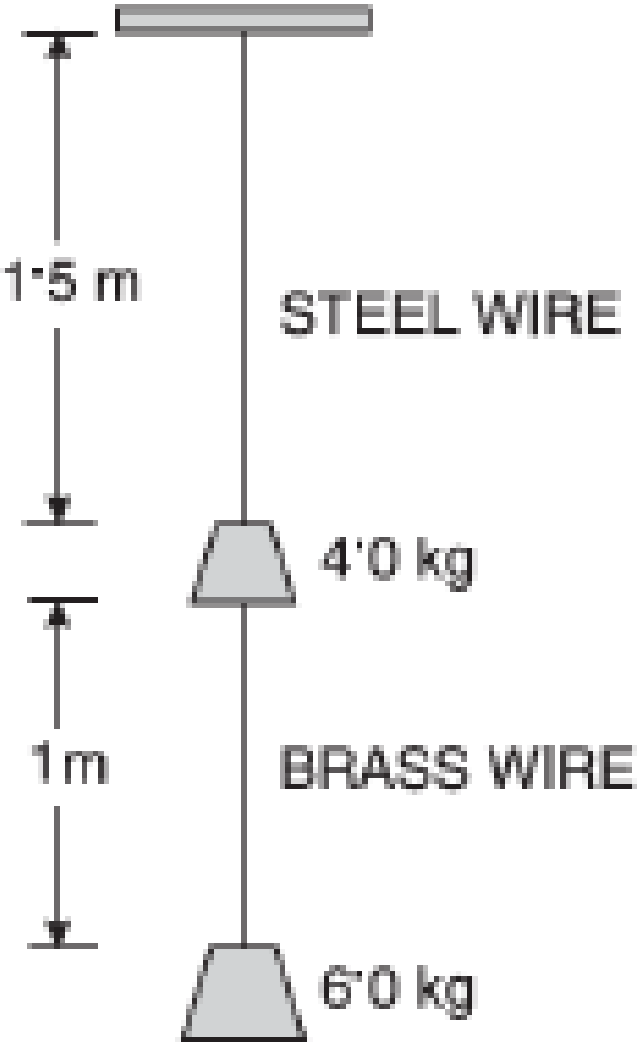
9. Find the elongation of the steel and brass wire in the Fig. Unloaded length of steel wire-1.5 m, unloaded length of brass wires 1 m, diameter of each wire 0.3 cm. Young's modulus for steel-$20x10^{10}Pa$ and that for brass=

$90x10^{10}Pa$



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10. A mass of 5.0 kg is hung from a copper wire of 5 mm diameter and 2 m in length. Calculate the extension produced. What should be the minimum. diameter of the wire, so that its elastic limit is not exceeded? Elastic limit for copper=$1.5x10^{9}dy \neq cm^{-2}$ and Y for copper-1.1 x10^12 dyne cm^2.

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11. A 45 kg traffic light is suspended with two steel wires of equal lengths and radii 0.5cm. if

the wires make an angle of 15° with the horizontal, what is the fractional increase in their length due to the weight of the light? given youngs modulus of Steel = $2 \times 10^{11} Nm^{-2}$

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12. A wire suspended vertically from one of its ends is stretched by attaching a weight of 200 N to the lower end. The weight stretches the

wire by 1 mm. Find the elastic energy stored in the wire.

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13. If S is stress and Y is Young's modulus of material of a wire, find the energy stored in the wire per unit volume in terms of S and Y.

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14. By how much the pressure on one litre of water be changed to compress it by 0.1 % ? Given that bulk modulus of the water - 2.2×10^9 Pa.

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15. The pressure of a medium is changed from 1.01×10^5Pa to 1.165×10^5 Pa and change in volume is 10% keeping temperature constant. Find the bulk modulus of the medium.

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16. Two metal plates are held together by two rivets width radii of 0.2 cm. If the maximum shear stress a single rivet can withstand is $5 \times 10^8 Nm^2$, how much force must be applied parallel to the plates to shear off both the rivets?

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17. A square lead slab of side 50 cm and thickness 50 cm is subjected to a shearing force (on its narrow face) of magnitude $9.0 \times 10^4 N$. The lower edge is riveted to the floor. How much is the upper edge displaced, if the shear modulus of lead is 5.6×10^9 Pa?

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18. A stone of 0.5 kg mass is attached to one end of a 0.8 m long aluminium wire of 0.7 mm

diameter and suspended vertically . The stone is now rotated in a horizontal plane at a rate such that the wire makes an angle of 85° with the vertical . find the increase in the length of the wire . The Young's modulus of aluminium = $7 \times 10^{10} Nm^{-2}$, $\sin 85^\circ$ = 0.9962 , cos 85° = 0.0872

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19. A load of 31.4 kg is suspended from a wire of radius 10^{-3} m and density $9 \times 10^3 kgm^{-3}$,

Calculate the change in temperature of the wire, if 75% of the work done is converted into heat. Given that Young's modulus and heat. capacity of the material of the wire are $9.8 \times 10^{10} Nm^{-2}$ and $490 Jkg^{-1} K^{-1}$ respectively.

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20. What is deforming force?

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21. which is a property of a body that opposes its deformation?

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22. under what condition, the restoring forces are equal and opposite to the external deforming force?

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23. Which of the two forces deforming or restoring is responsible for elastic behaviour of a substance?

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24. State Hooke's law.

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25. what is the limitation of hooke`s law?

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26. define stress and give its SI unit

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27. what are the factors on which modulus of elasticity of a material depends?

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28. Why do we prefer steel to manufacture a spring?

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29. In stretching a wire, work has to be performed. Why?

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30. When a wire is stretched, work has to be done. What happens to the work done during the stretching of the wire?

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31. Which of the three elastic moduli possible in all the three states of matter?

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32. A hard wire is broken by bending it repeatedly in opposite direction. Why?

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33. what is meant by elastic fatigue?

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34. why any metallic part of a machinery is never subjected to a stress beyond the elastic

limit of the material?

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35. What is an elastomer?

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36. Why are electric poles given hollow structure?

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37. Name factors which affect the property of elasticity of a solid.

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38. Distinguish between elasticity and plasticity.

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39. Elasticity has different meaning in physics and in our daily life. Comment.

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40. What is the cause of elasticity?

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41. represent graphically the variation of extension with load in an elastic body. On the

graph, mark: Hooke's law region

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42. represent graphically the variation of extension with load in an elastic body. On the graph, mark: Elastic limit

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43. represent graphically the variation of extension with load in an elastic body. On the

graph, mark: Yield point

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44. represent graphically the variation of extension with load in an elastic body. On the graph, mark: breaking point

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45. Draw a schematic of a graph of the applied force versus resulting elongation of a metallic

wire. Show the elastic limit on this graph. What feature of this graph is related to the value of Young's modulus of material of wire?

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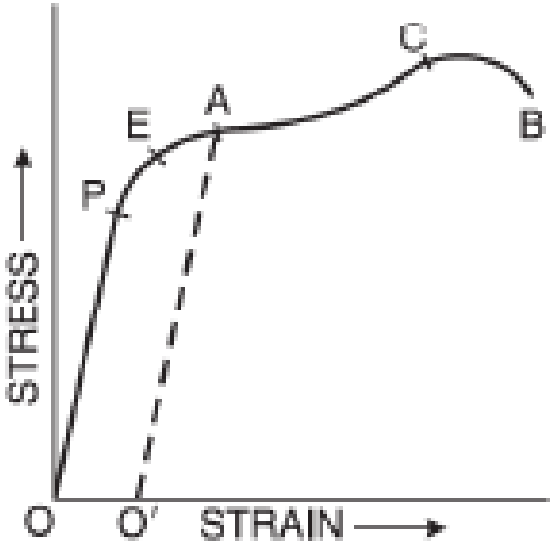
46. The stress-strain graph for a metal wire shown in the Fig. Upto the point E, the wire returns to its original state O along the curve EPO, when it is gradually unloaded. The point B corresponds to the fracture of the wire. Upto what point on the curve is Hooke's law

obeyed? (This point is sometimes called 'proportional limit').



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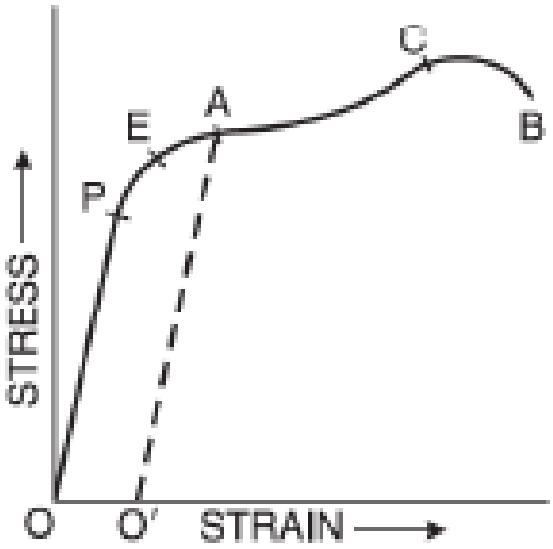
47. The stress-strain graph for a metal wire shown in the Fig. Upto the point E, the wire

returns to its original state O along the curve EPO, when it is gradually unloaded. The point B corresponds to the fracture of the wire. Which point on the curve corresponds to 'elastic limit' or 'yield point of the wire ?



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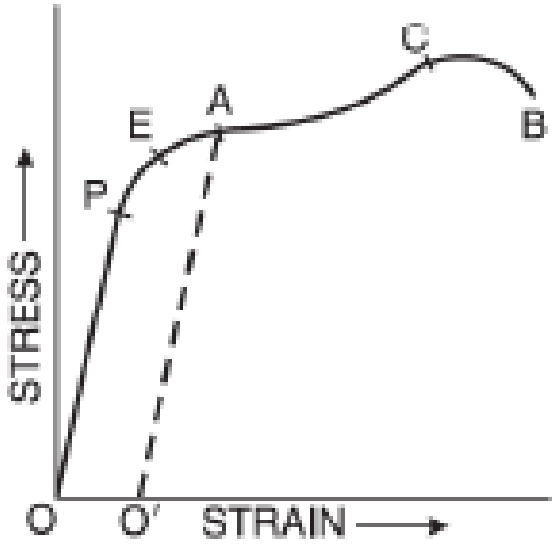
48. The stress-strain graph for a metal wire shown in the Fig. Upto the point E, the wire returns to its original state O along the curve EPO, when it is gradually unloaded. The point B corresponds to the fracture of the wire. Indicate the elastic and plastic regions of the stress-strain graph.



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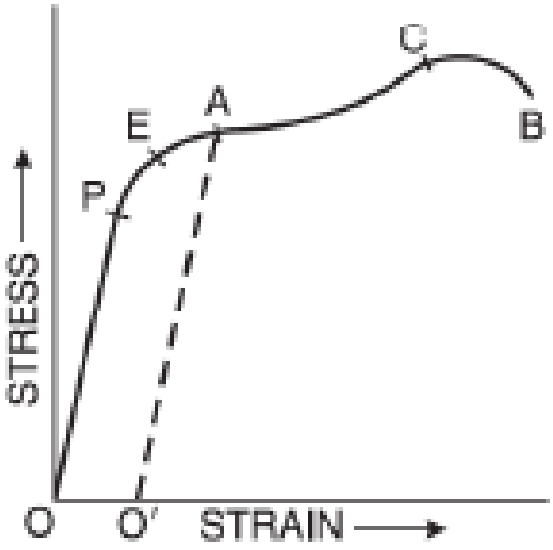
49. The stress-strain graph for a metal wire shown in the Fig. Upto the point E, the wire returns to its original state O along the curve EPO, when it is gradually unloaded. The point B corresponds to the fracture of the wire. Describe what happens, when the wire is loaded up to a stress corres-ponding to the point A on the graph and then unloaded gradually. In particular, explain the dotted

curve.



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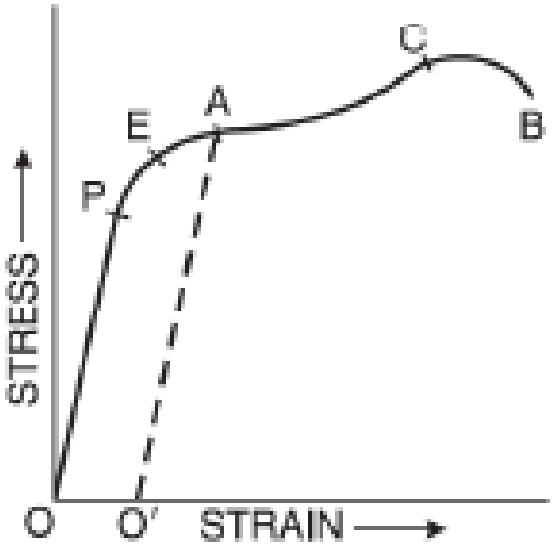
50. The stress-strain graph for a metal wire shown in the Fig. Upto the point E, the wire returns to its original state O along the curve

EPO, when it is gradually unloaded. The point B corresponds to the fracture of the wire. Indicate the elastic and plastic regions of the stress-strain graph.



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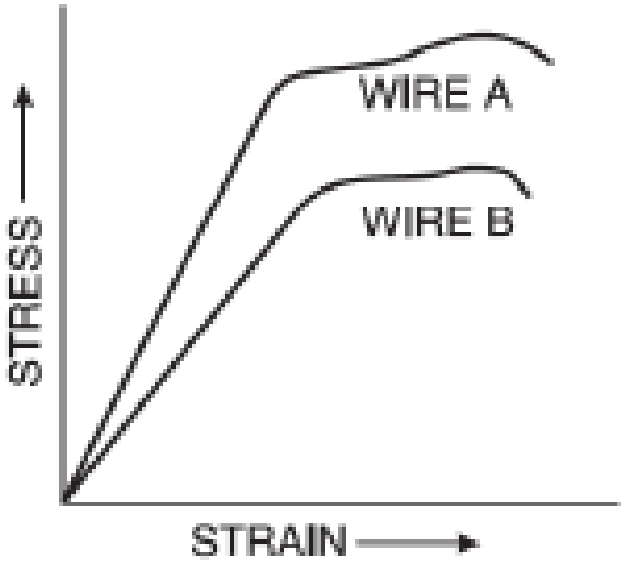
51. The stress versus strain graphs for wires of two materials A and B are as shown in Fig. Which material is more ductile ?



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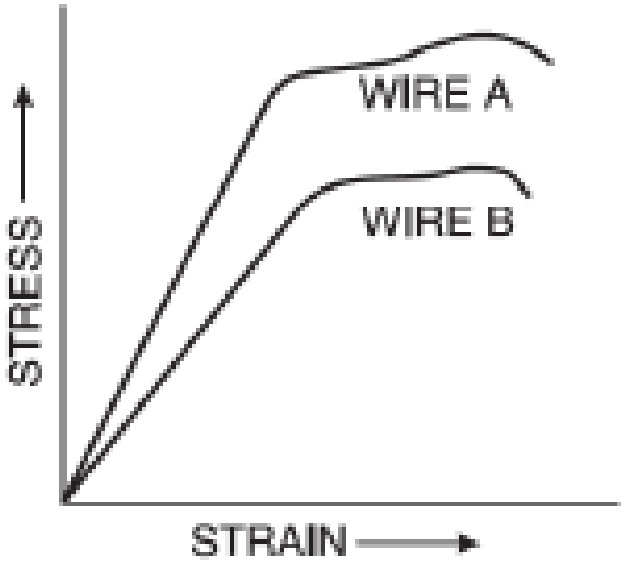
52. The stress versus strain graphs for wires of two materials A and B are as shown in Fig. Which material is more brittle?



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53. Why do we prefer steel to manufacture a spring?

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54. The length of a wire increases by 8mm. Then a weight of 3 kg is hung. if all conditions are the same, what will be the increase in its length when diameter is doubled?

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55. A wire stretches by a certain amount under a load. If the load and radius are both increased to four times, find the stretch caused in the wire.

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56. Two wires of different materials are suspended from a rigid support. They have same length and diameter and carry the sameload at the free ends. Will extension, strain and stress be different?

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57. Steel is more elastic than rubber. Explain why?

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58. The length of a metallic wire is L_1 : when tension on the wie is T_1 , and length is L_2, when the tension in the wire is T_2 , Find original length of the wire.

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59. An elastic wire is cut to half its original length. How would it affect the maximum load that the wire can support?

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60. The breaking force for a wire is F. what will be the breaking force for two parallel wires of the same size?

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61. The breaking force for a wire is F, what will be the breaking force for a single wire of double the thickness?

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62. A cable is replaced by another of the same length and material but of twice diameter. How does this affect elongation under a given load?

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63. A cable is replaced by another of the same length and material of twice diameter. How many times will be the maximum load supported by the latter as compared to the former?

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64. Why do spring balances show wrong readings after they have been used for a long

time?

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65. Why bridges are declared unsafe after long use?

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66. Read the following two statements below carefully and state, with reasons, if it is true or

false. The Young's modulus of rubber is greater than that of steel,

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67. Read the following two statements below carefully and state, with reasons, if it is true or false. The stretching of a coil is determined by its shear modulus.

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68. read the statement below carefully and state with reasons if it is true or false. When a material is under tensile stress the restoring forces are caused by Inter atomic attraction while under compressional stress the restoring forces are due to interatomic repulsion.

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69. Graphite consists of plains of carbon atoms. sach carbon atoms in the plains are held by very weak forces. what kind of elastic properties do you expect from graphite?

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70. Why a solid is ductile or brittle?

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71. Find stress, strain and Young's modulus of elasticity in the case of a wire 1.5 m long and $1mm^2$ in cross-section, if it increases by 1.55 mm in length, when a weight of 10 kg is suspended from it.

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72. A structural steel rod has a radius of 10 mm and a length of 1.0 m. A 100 kN force stretches it along its length. Calculate stress.

Young's modulus of structural steel is $2.0 \times 10^{11} Nm^{-2}$

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73. A structural steel rod has a radius of 10 mm and a length of 1.0 m. A 100 kN force stretches it along its length. Calculate elongation. Young's modulus of structural steel is $2.0 \times 10^{11} Nm^{-2}$

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74. A structural steel rod has a radius of 10 mm and a length of 1.0 m. A 100 kN force stretches it along its length. Calculate strain on the rod. Young's modulus of structural steel is $2.0 \times 10^{11} Nm^{-2}$

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75. What force is required to stretch a copper wire $1cm^2$ in cross-section to double its length? Y for copper is 1.26×10^{12} dyne. cm

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76. Determine the force required to double the length of a steel wire of area of cross section $5 \times 10^{-5} m^2$ Young's modulus of steel- $2 \times 10^{11} Nm^{-2}$

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77. A load of 2 kg produces an extension of 1 mm in a wire 3 mm in length and 1 mm in

diameter Calculate the Young's modulus of the wire

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78. Calculate the percentage increase in length of a wire of diameter 2 mm stretched by force of 1 kgf. Young's modulus of the material of wire $15 \times 10^{10} Nm^{-2}$

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79. Find the maximum length of the steel wire that can hang without breaking. Given that breaking stress for steel $7.9x10^{11}Nm^{-2}$ and density of steel- $7.9 \times 10^{3}kgm^{-3}$

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80. A silica glass rod has a diameter of 1 cm and is 10 cm long. Estimate the largest mass that can be hung from it without breaking it. Given that Young's modulus of silica -6.5

xx10^10 Nm^-2

and $break \in gstressf$ or $silica -$

5.0xx10^7Nm^{-2}

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81. A steel wire of length 5.0 m and cross-section $3.0 \times 10^{-5} m^2$ stretches by the same amount as a copper wire of length 3.0 m and cross-section $4.0 \times 10^{-5} m^2$ under a given load. What is the ratio of Young's modulus of steel to that of copper?

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82. A mass of 5.0 kg is hung from a copper wire of 5 mm diameter and 2 m in length. Calculate the extension produced. What should be the minimum. diameter of the wire, so that its elastic limit is not exceeded? Elastic limit for copper=$1.5x10^{9}dy \neq cm^{-2}$ and Y for copper-1.1 x10^12 dyne cm^2.

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83. The average depth of Indian ocean is 3 km. Find the fractional compression of water at the bottom of the ocean, given that bulk modulus of water id $2.2 \times 10^9 Nm^{-2}$.

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84. A solid ball 3 cm in diameter is submerged in a lake to a depth, where the pressure is $10^4 kgfm^{-2}$ Find the change in volume of the

ball, if bulk modulus of the material of the ball is $10^6 Nm^{-2}$

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85. When a metallic cube is subjected to a stress of $6 \times 10^9 Nm^{-2}$, each side of the cube gets shortened by 1%. Find volumetric strain and bulk modulus of the metal.

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86. A solid ball 300 cm in diameter is submerged in a lake a such a depth that the pressure exerted by water is $1.0kgfcm^{-2}$. Find the change in volume of the ball at this depth k for material of the ball = $1.0 \times 10^{13} dy \neq cm^{-2}$

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87. A sphere contracts to 0.01% volume, when taken to the bottom of sea 1 km deep. Find the

bulk modulus of the material of the sphere. Density of sea water = $1.0 \times 10^3 kg/m^3$.

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88. If the normal density of sea water is $1.00 g/cm^3$, what will be its density at a depth of 3km? Given compressibility of water = 5×10^{-5} per atmosphere. 1 atmospheric pressure $=10^6 dy \neq /cm^2$, g= $980 cm/s^2$.

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89. What is the density of lead under a pressure of $2 \times 10^8 Nm^{-2}$, if the bulk modulus of lead is $8 \times 10^9 Nm^{-2}$ and normal density of lead is $11.4 gcm^{-3}$?

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90. A metallic cube whose each side is 10 cm is subjected to a shearing force of 100 kgf. The top face is displaced through 0.25 cm with respect to the bottom ? Calculate the shearing stress, strain and shear modulus.

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91. An Indian rubber cube of side 7 cm has one side fixed, while a tangential force equal to the weight of 200 kilogram is applied to the opposite face. Find the shearing strain produced and distance through which th strained side moves. Modulus of rigidity for rubber is $2 \times 10^7 dy \neq cm^{-2}$

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92. The Young's modulus for Steel is $2.0 \times 10^{11} Nm^{-2}$. If the interatomic spacing for the metal is $2.8\overset{\circ}{A}$, find the increase in the interatomic spacing for a force of $10^{9} Nm^{-2}$

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93. A stress of $10^{6} N/m^{2}$ is required for breaking a material. If the density of the material is $3 \times 10^{3} Kg/m^{3}$, then what should be the minimum length of the wire made of

the same material so that it breaks by its own weight $\left(g = 10m/s^2\right)$

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94. An Indian rubber cord 10 m long is suspended vertically How much does it stretch under its own weight Density of rubber= $1.5 \times 10^3 kgm^{-3}$ and Young's modulus of rubber - $5 \times 10^8 Nm^{-2}$

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95. A mass of 100 g is attached to the end of a rubber string 49 cm long and of cross-sectional area 20 mm^2 When the mass is whirled round at a constant angular speed of 40 rps, it moves along a circular path of radius 51 cm. Find young's modulus of rubber.

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96. A rubber cord catapult has a cross sectional area $1mm^2$ and total unstretched length of 10cm. It is stretched to 12cm and

then released to project a missile of mass 5g. Find the velocity of projection of missile and tension in the cord. Young's modulus = $5 \times 10^8 Nm^{-2}$

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97. Two parallel steel wires A and B are fixed to rigid support at the upper ends and subjected to the same load at the lower ends The lengths of the wires are in the ratio 4:5 and their radii are in the ratio 4:3. The increase in

the length of the wire A is 1 mm. Calculate the increase in the length of the wire B.

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98. A steel wire and copper wire of the same diameter and of length 1m and 2m respectively are connected end to end and a force is applied. The increase in length of the combination is 0.01m.Calculate the elongation produced in the individual wires. Given that Y

of copper is 12 x 10^(10) Nm^(2) and that of steel is 20 x 10^(10) N m^(-2).

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99. A composite wire of uniform diameter 3 mm consists of a copper wire of length 2.2 m and a steel wire of length 1.6m stretches under a load by 0.7 mm Calculate the load, given that the Young's modulus for copper in 1.1×10^{11} Pa and that for steel is 20×10^{11} Pa.

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100. A wire loaded by a weight of density $7.8gcm^{-3}$ is found to be of length 95cm. On immersing the weight in water, the length decreased by 0.19cm. Find the original length of the wire.

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101. A light rod of length 2m is suspended from the ceiling horizontally by means of two vertical wires of equal length tied to its ends.

One of the wire is made of steel and is of cross section $0.1cm^2$ and other is of brass of cross section $0.2cm^2$ Find out the position along the rod at which a weight may be hung to produce equal stresses in both the wires.

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102. A light rod of length 2m is suspended from the ceiling horizontally by means of two vertical wires of equal length tied to its ends. One of the wire is made of steel and is of cross

section $10^{-3}m^2$ and other is of brass of cross section $2 \times 10^{-2}m^2$ Find out the position along the rod at which a weight may be hung to produce equal stresses in both the wires.

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Exercise

1. Discuss stress-strain graph.

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2. Define stress and strain. Also describe briefly the types of stress and strain.

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3. Give SI unit of Young's modulus of elasticity.

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4. Define modulus of rigidity. Give its units and dimensions.

Watch Video Solution

5. Steel is more elastic than rubber. Explain why?

Watch Video Solution

6. Steel is more elastic than rubber. Explain why?

Watch Video Solution

7. Hollow shafts are preferred to solid shafts for transmitting torque. Explain.

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8. What are ductile materials?

Watch Video Solution

9. Why do spring balances show wrong readings after they have been used for a long time?

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10. Define potential enrgy of a body .Find an expression for the potential energy of a stretched spring.

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11. Define Young's modulus of elasticitiy. normal stress and longitudinal strain. Give unit of each of them. Derive an expression for

the elastic potential energy of a wire, when stretched.

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12. Draw stress-strain curve for aa loaded steel wire and hence define te terms permanent set, elastic limit, yield point and tensile strength.

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13. Define Young's modulus of elasticitiy. normal stress and longitudinal strain. Give unit of each of them. Derive an expression for the elastic potential energy of a wire, when stretched.

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14. What is elastic after effect and elastic fatigue?

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15. Two rods one is hollow and other is solid of same length and made of same material having same modulus of rigidity. Prove that hollow rod is stronger than solid rod.

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