Answers

Young's Modulus and Breaking Stress

1	c	2	b	3	d	4	c	5	b
6	c	7	c	8	c	9	b	10	c
11	d	12	a	13	b	14	d	15	a
16	c	17	a	18	a	19	d	20	c
21	b	22	b	23	b	24	d	25	b
26	d	27	c	28	b	29	b	30	b
31	b	32	c	33	d	34	b	35	a
36	b	37	a	38	b	39	d	40	a
41	c	42	d	43	c	44	a	45	b
46	d	47	a	48	c	49	d	50	c
51	c	52	a	53	c	54	a	55	b
56	a	57	a	58	d	59	a	60	a
61	c	62	b	63	d	64	b	65	a
66	c	67	d	68	b	69	a	70	d
71	b	72	d	73	c	74	c	75	a
76	a	77	d	78	d	79	a	80	a
81	d	82	d	83	a	84	d	85	a
86	c	87	c	88	b	89	b	90	c
91	c	92	c	93	b	94	c	95	c
96	b	97	d	98	b	99	a	100	b
101	b	102	a	103	b	104	d	105	b
106	a	107	d	108	d	109	c	110	d
111	c	112	c	113	c	114	d	115	d
116	b	117	d	118	a	119	c	120	a
121	a	122	a	123	b	124	b	125	b

Bulk Modulus

1	c	2	c	3	b	4	d	5	b
6	d	7	a	8	d	9	c	10	c
11	b	12	c	13	d	14	a	15	c
16	b	17	c	18	c	19	a	20	d
21	b								

Rigidity Modulus

1	b	2	d	3	c	4	d	5	c
6	a	7	a	8	b	9	c	10	d
11	d	12	b	13	d	14	b	15	c
16	b	17	d	18	c				

Work Done in Stretching a Wire

1	d	2	b	3	c	4	a	5	b
6	c	7	d	8	c	9	b	10	b
11	c	12	a	13	d	14	a	15	a
16	a	17	b	18	a	19	c	20	d
21	b	22	c	23	c	24	c	25	b
26	a	27	b	28	a	29	a	30	b

Critical Thinking Questions

1	b	2	a	3	c	4	a	5	c
6	d	7	c	8	b				

Graphical Questions

1	d	2	a	3	c	4	c	5	d
6	a	7	d	8	a	9	a	10	b
11	c	12	b	13	b	14	b	15	d
16	a	17	c	18	d	19	c		

Assertion and Reason

1	a	2	e	3	a	4	d	5	a
6	a	7	c	8	a	9	d	10	a
11	a	12	b						

AS Answers and Solutions

Young's Modulus and Breaking Stress

1. (c) $l = \frac{FL}{YA} \Rightarrow l \propto \frac{1}{A}$

2. (b) Stress $\propto$ Strain $\Rightarrow$ Stress $\propto \frac{l}{L}$

3. (d) $Y = \frac{F}{A}\frac{L}{A} \Rightarrow l \propto \frac{L}{A} \propto \frac{L}{\pi d^2}$

$\therefore\ l \propto \frac{L}{d^2}$ [As F and Y are constant]

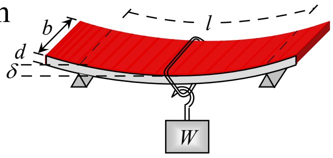
The ratio of $\frac{L}{d^2}$ is maximum for case (d)

4. (c) $l = \frac{FL}{AY} \Rightarrow l \propto \frac{L}{d^2} \Rightarrow \frac{l_1}{l_2} = \frac{L_1}{L_2} \times \left(\frac{d_2}{d_1}\right)^2$

$= \frac{1}{2} \times \left(\frac{1}{2}\right)^2 = \frac{1}{8}$

5. (b) Young's modulus of wire does not varies with dimension of wire. It is the property of given material.

6. (c) Depression in beam



$\delta = \frac{WL^3}{4Ybd^3}$

$\therefore \delta \propto \frac{1}{Y}$

7. (c) $l = \frac{FL}{AY} \Rightarrow l \propto \frac{1}{r^2}$ (*F*, *L* and *Y* are constant)

$\frac{l_2}{l_1} = \left(\frac{r_1}{r_2}\right)^2 = (2)^2 = 4 \Rightarrow l_2 = 4l_1 = 4\,cm$

8. (c)

9. (b) $l \propto \frac{1}{r^2}$. If radius of the wire is doubled then increment in length will become $\frac{1}{4}$ times

i.e. $\frac{12}{4} = 3\,mm$

10. (c) $l = \frac{mgL}{AY} = \frac{1 \times 10 \times 1.1}{1.1 \times 10^{11} \times 10^{-6}}\,m = 0.1\,mm$

11. (d) $F = \frac{YAl}{L} = \frac{2.2 \times 10^{11} \times 2 \times 10^{-6} \times 5 \times 10^{-4}}{2} = 1.1 \times 10^2\,N$

12. (a) Interatomic force constant $K = Y \times r_0$

$= 2 \times 10^{11} \times 3 \times 10^{-10} = 60\ N/m$

13. (b) To double the length of wire, Stress = Young's modulus

$\therefore \frac{F}{A} = 2 \times 10^{12} \frac{dyne}{cm^2}$.

If $A = 1$ then $F = 2 \times 10^{12}$ *dyne*

14. (d)

15. (a) Because due to increase in temperature intermolecular forces decreases.

16. (c) Breaking Force ∝ Area of cross section of wire (πr^2)

If radius of wire is double then breaking force will become four times.

17. (a) $Y = 3K(1 - 2\sigma)$ and $Y = 2\eta(1 + \sigma)$

Eliminating σ we get $Y = \frac{9\eta K}{\eta + 3K}$

18. (a) $F = \frac{YAl}{L} = \frac{9 \times 10^{10} \times \pi \times 4 \times 10^{-6} \times 0.1}{100} = 360\,\pi\ N$

19. (d) Energy stored per unit volume

$= \frac{1}{2} \times \text{Stress} \times \text{Strain}$

$= \frac{1}{2} \times \text{Young's modulus} \times (\text{Strain})^2 = \frac{1}{2} \times Y \times x^2$

20. (c) $l \propto L$ *i.e.* if length is reduced to half then increase in length will be $\frac{l}{2}$.

21. (b) $l = \frac{L^2 dg}{2Y} = \frac{(8 \times 10^{-2})^2 \times 1.5 \times 9.8}{2 \times 5 \times 10^8} = 9.6 \times 10^{-11}\,m$

22. (b) $\text{Stress} = \frac{\text{force}}{\text{Area}}$ $\therefore$ $\text{Stress} \propto \frac{1}{\pi r^2}$

$\frac{S_B}{S_A} = \left(\frac{r_A}{r_B}\right)^2 = (2)^2 \Rightarrow S_B = 4S_A$

23. (b) Breaking force ∝ Area of cross section of wire

i.e. load hold by the wire does not depend upon the length of the wire.

24. (d) If length of wire doubled then strain = 1

$Y = \text{stress} \Rightarrow F = Y \times A = 10^{12} \times 0.5$

$= 0.5 \times 10^{12}\,dyne$

25. (b) Due to elastic fatigue its elastic property decreases.

26. (d) $l = \frac{FL}{AY} \Rightarrow l \propto \frac{1}{r^2}$ (*F*,*L* and *Y* are same)

$\frac{l_A}{l_B} = \left(\frac{r_B}{r_A}\right)^2 = \left(\frac{r_B}{2r_B}\right)^2 = \frac{1}{4} \Rightarrow l_A = 4l_B$ or $l_B = \frac{l_A}{4}$

27. (c)

28. (b) $l = \frac{FL}{AY} \Rightarrow \frac{l_S}{l_{cu}} = \frac{Y_{cu}}{Y_S}$ (*F*,*L* and *Y* are constant)

$\therefore \frac{l_s}{l_{cu}} = \frac{1.2 \times 10^{11}}{2 \times 10^{11}} = \frac{3}{5}$

29. (b) If length of the wire is doubled then strain = 1

$\therefore$ Y $= \text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{2 \times 10^5}{2} = 10^5 \frac{dyne}{cm^2}$

30. (b) $l = \frac{FL}{AY} \Rightarrow l \propto \frac{L}{r^2}$ (*F* and *Y* are same)

$\therefore \frac{l_2}{l_1} = \frac{L_2}{L_1}\left(\frac{r_1}{r_2}\right)^2 = 2 \times \left(\frac{1}{2}\right)^2 = \frac{1}{2} \Rightarrow l_2 = \frac{l_1}{2} = \frac{l}{2} = 0.5mm$

31. (b) F = force developed $= YA\alpha(\Delta\theta)$

$= 10^{11} \times 10^{-4} \times 10^{-5} \times 100 = 10^4\,N$

32. (c) $F = YA\alpha\Delta\theta \therefore F \propto A$

33. (d) $Y = \frac{F/A}{\text{strain}} \Rightarrow A = \frac{F}{Y \times \text{strain}} = \frac{10^4}{7 \times 10^9 \times 0.002}$

$= \frac{1}{14} \times 10^{-2} = 7.1 \times 10^{-4} m^2$

34. (b) $\text{strain} \propto \text{stress} \propto \frac{F}{A}$

Ratio of strain $= \frac{A_2}{A_1} = \left(\frac{r_2}{r_1}\right)^2 = \left(\frac{4}{1}\right)^2 = \frac{16}{1}$

35. (a) $F = 2000 N, L = 6 m, l = 0.5\ cm, A = 10^{-6} m^2$

$Y = \frac{FL}{Al} = \frac{2000 \times 6}{10^{-6} \times 0.5 \times 10^{-2}} = 2.35 \times 10^{12}\ N/m^2$

36. (b) $F = Kx \Rightarrow K = \frac{F}{x} = \frac{9 \times 9.8}{4.5 \times 10^{-3}} = 1.96 \times 10^4\ N/m$

37. (a) $l \propto \frac{FL}{r^2 Y} \Rightarrow l \propto \frac{1}{r^2}$ (F, L and Y are constant)

$\frac{l_2}{l_1} = \left(\frac{r_1}{r_2}\right)^2 = (n)^2 \Rightarrow l_2 = n^2 l_1$

38. (b) Longitudinal strain $\frac{l}{L} = \frac{\text{stress}}{Y} = \frac{10^6}{10^{11}} = 10^{-5}$

Percentage increase in length $= 10^{-5} \times 100 = 0.001\%$

39. (d) It is the specific property of a particular metal at a given temperature which can be changed only by temperature variations.

40. (a) $Y = \frac{3.6 \times 10^{-9} N/Å}{3 \times 10^{-10} m} = 1.2 \times 10^{11} N/m^2$

41. (c)

42. (d) $K = \frac{YA}{L} = \frac{Y \times \pi r^2}{L} \Rightarrow K \propto \frac{Yr^2}{L}$

i.e. force constant of a wire depends on young's modules (nature of the material), radius of the wire and length of the wire.

43. (c)

44. (a)

45. (b)

46. (d) Increase in tension of wire $= YA\alpha\Delta\theta$

$= 8 \times 10^{-6} \times 2.2 \times 10^{11} \times 10^{-2} \times 10^{-4} \times 5 = 8.8\ N$

47. (a) A small change in pressure produces a large change in volume.

48. (c) $W = \frac{1}{2}\frac{YAl^2}{L} \Rightarrow 0.4 = \frac{1}{2} \times \frac{Y \times 1^{-6} \times (0.2 \times 10^{-2})^2}{1}$

$\therefore Y = 2 \times 10^{11} N/m^2$

49. (d)

50. (c) $Y = 3K(1 - 2\sigma)$

$\sigma = \frac{3K - Y}{6K} = \frac{3 \times 11 \times 10^{10} - 7.25 \times 10^{10}}{6 \times 11 \times 10^{10}} \Rightarrow \sigma = 0.39$

51. (c)

52. (a) If density of the material increases then more force (stress) is required for same deformation *i.e.* the value of young's modulus increases.

53. (c) $Y = 10^4 N/m^2, A = 2 \times 10^{-4} m^2, F = 2 \times 10^5 dyne = 2N$

$l = \frac{FL}{AY} = \frac{2 \times L}{2 \times 10^{-4} \times 10^4} = L$

$\therefore$ Final length = initial length + increment = $2L$

54. (a)

55. (b) Y is defined for solid only and for powders, $Y = 0$

56. (a)

57. (a) $l = \frac{FL}{AY} = \frac{FL}{\pi r^2 Y} \therefore l \propto \frac{FL}{r^2}$ (Y = constant)

$\therefore \frac{l_2}{l_1} = \frac{F_2}{F_1} \times \frac{L_2}{L_1}\left(\frac{r_1}{r_2}\right)^2 = 2 \times 2 \times \left(\frac{1}{2}\right)^2 = 1$

$\therefore l_2 = l_1$ *i.e.* increment in its length will be l.

58. (d) Breaking stress = strain × Young's modulus

$= 0.15 \times 2 \times^{11} = 3 \times 10^{10}\ Nm^{-2}$

59. (a) In accordance with Hooke's law.

60. (a) $F = A \times Y \times \text{strain} = 1 \times 10^{-4} \times 2 \times 10^{11} \times 0.1 = 2 \times 10^6 N$

61. (c)

62. (b) Because strain is a dimensionless and unitless quantity.

63. (d) $\text{Stress} = \frac{\text{Force}}{\text{area}}$.

In the present case, force applied and area of cross-section of wires are same, therefore stress has to be the same.

$\text{Strain} = \frac{\text{Stress}}{Y}$

Since the Young's modulus of steel wire is greater than the copper wire, therefore, strain in case of steel wire is less than that in case of copper wire.

64. (b) Initial length (circumference) of the ring = $2\pi r$

Final length (circumference) of the ring = $2\pi R$

Change in length = $2\pi R - 2\pi r$.

$$\text{strain} = \frac{\text{change in length}}{\text{original length}} = \frac{2\pi(R-r)}{2\pi r} = \frac{R-r}{r}$$

Now Young's modulus $E = \frac{F/A}{l/L} = \frac{F/A}{(R-r)/r}$

$$\therefore F = AE\left(\frac{R-r}{r}\right)$$

65. (a) $l = \frac{FL}{\pi r^2 r} \Rightarrow l \propto \frac{F}{r^2}$ (*Y* and *L* are constant)

$$\frac{l_2}{l_1} = \frac{F_2}{F_1} \times \left(\frac{r_1}{r_2}\right)^2 = 2 \times (2)^2 = 8 \;\therefore\; l_2 = 8l_1 = 8 \times 1 = 8mm$$

66. (c) $l = \frac{FL}{\pi r^2 Y} \Rightarrow l \propto \frac{L}{r^2}$ (*F* and *Y* are constant)

$$\frac{l_1}{l_2} = \frac{L_1}{L_2}\left(\frac{r_2}{r_1}\right)^2 = \frac{1}{2}\left(\sqrt{2}\right)^2 \therefore \frac{l_1}{l_2} = 1:1$$

67. (d) $l \propto \frac{1}{r^2}$ (*F*,*L* and *Y* are constant)

$$\frac{l_2}{l_1} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{1}{2}\right)^2 \Rightarrow l_2 = \frac{l_1}{4} = \frac{2.4}{4} \Rightarrow l_2 = 0.6\ cm$$

68. (b) $F = Y \times A \times \frac{l}{L} \Rightarrow F \propto r^2$ (*Y*,*l* and *L* are constant)

If diameter is made four times then force required will be 16 times. *i.e.* $16 \times 10^3\ N$

69. (a) $F = Y \times A \times \frac{l}{L} \Rightarrow F \propto \frac{r^2}{L}$ (*Y* and *l* are constant)

$$\therefore \frac{F_1}{F_2} = \left(\frac{r_1}{r_2}\right)^2\left(\frac{L_2}{L_1}\right) = \left(\frac{2}{1}\right)^2\left(\frac{1}{4}\right) = 1 \Rightarrow \frac{F_1}{F_2} = 1:1$$

70. (d) Increment in length $l = \frac{L^2 dg}{2Y} \;\therefore\; l \propto L^2 d$

71. (b) Adiabatic elasticity $E = \gamma P$

For argon $E_{Ar} = 1.6\ P$ ….(i)

For hydrogen $E_{H2} = 1.4P$ ….(ii)

As elasticity of hydrogen and argon are equal

$$\therefore 1.6P = 1.4P \Rightarrow P = \frac{8}{7}P$$

72. (d)

73. (c) $l = \frac{FL}{AY} = \frac{FL^2}{(AL)Y} = \frac{FL^2}{VY}$.

If volume is fixed then $l \propto L^2$

74. (c) $F = YA\alpha\Delta t = 2 \times 10^{11} \times 3 \times 10^{-6} \times 10^{-5} \times (20\text{–}10) = 60N$

75. (a) Because dimension of invar does not varies with temperature.

76. (a) $l = \frac{FL}{\pi r^2 Y} \;\therefore\; l \propto \frac{L}{r^2}$ (*Y* and *F* are constant)

$$\frac{l_2}{l_1} = \frac{L_2}{L_1} \times \left(\frac{r_1}{r_2}\right)^2 = (2) \times \left(\frac{1}{2}\right)^2 = \frac{1}{2}$$

$$\Rightarrow l_2 = \frac{l_1}{2} = \frac{0.01m}{2} = 0.005m$$

77. (d) Poisson's ratio varies between – 1 and 0.5

78. (d) $L_2 = l_2(1 + \alpha_2\Delta\theta)$ and $L_1 = l_1(1 + \alpha_1\Delta\theta)$

$$\Rightarrow (L_2 - L_1) = (l_2 - l_1) + \Delta\theta(l_2\alpha_2 - l_1\alpha_1)$$

Now $(L_2 - L_1) = (l_2 - l_1)$ so, $l_2\alpha_2 - l_1\alpha_1 = 0$

79. (a) Thermal stress = $Y\alpha\Delta\theta$

$$= 1.2 \times 10^{11} \times 1.1 \times 10^{-5} \times (20 - 10) = 1.32 \times 10^7\ N/m^2$$

80. (a) $l = \frac{FL}{AY} \Rightarrow l \propto \frac{1}{r^2}$ (*F*,*L* and *Y* are constant)

$$\frac{l_2}{l_1} = \left(\frac{r_1}{r_2}\right)^2 = (2)^2 \Rightarrow l_2 = 4l_1 = 4 \times 3 = 12mm$$

81. (d) $l = \frac{L^2 dg}{2Y} = \frac{(8)^2 \times 1.5 \times 10^3 \times 10}{2 \times 5 \times 10^6} = 9.6 \times 10^{-2}\,m$

82. (d) $l \propto \frac{L}{r^2}$ (*Y* and *F* are constant)

Maximum extension takes place in that wire for which the ratio of $\frac{L}{r^2}$ will be maximum.

83. (a)

84. (d)

85. (a) $Y = \frac{MgL}{Al} = \frac{250 \times 9.8 \times 2}{50 \times 10^{-6} \times 0.5 \times 10^{-3}}$

$$= 19.6 \times 10^{10}\ N/m^2$$

86. (c)

87. (c) $l = \frac{FL}{AY} \Rightarrow l \propto \frac{L}{r^2}$ (*F* and *Y* are constant)

$$\frac{l_2}{l_1} = \frac{L_2}{L_1} \times \left(\frac{r_1}{r_2}\right)^2 = 2 \times \left(\frac{1}{2}\right)^2 = \frac{1}{2} \therefore l_2 = \frac{l_1}{2}$$

i.e. the change in the length of other wire is $\frac{l}{2}$

88. (b)

89. (b)

90. (c) $l = \frac{MgL}{YA} = \frac{1 \times 10 \times 1}{2 \times 10^{11} \times 10^{-6}} = 0.05\ mm$

91. (c) $l = \frac{FL}{AY} \therefore l \propto \frac{F}{r^2}$

$$\frac{l_1}{l_2} = \frac{F_2}{F_1}\left(\frac{r_1}{r_2}\right)^2 = (4) \times \left(\frac{1}{2}\right)^2 = 1 \;\therefore\; l_2 = l_1 = 1mm$$

92. (c)

93. (b) $l = \frac{FL}{AY} \therefore l \propto \frac{1}{A}$ (*F*,*L* and *Y* are constant)

$$\frac{A_2}{A_1} = \frac{l_1}{l_2} \Rightarrow A_2 = A_1\left(\frac{0.1}{0.05}\right) = 2A_1 = 2 \times 4 = 8mm^2$$

94. (c) $l = \frac{FL}{\pi r^2 Y} \Rightarrow r^2 \propto \frac{1}{Y}$ (*F*,*L* and *l* are constant)

$\frac{r_2}{r_1} = \left(\frac{Y_1}{Y_2}\right)^{1/2} = \left(\frac{7\times10^{10}}{12\times10^{10}}\right)^{1/2}$

$\Rightarrow r_2 = 1.5\times\left(\frac{7}{12}\right)^{1/2}$ = 1.145 *mm* ∴ dia = 2.29 *mm*

95. (c) $F = \frac{YAl}{L} = 0.9\times10^{11}\times\pi\times(0.3\times10^{-3})^2\times\frac{0.2}{100} = 51\ N$

96. (b) Young's modules $= \frac{\text{stress}}{\text{strain}}$

As the length of wire get doubled therefore strain = 1

∴ *Y* = strain = 20 ×10⁸ *N/ m*²

97. (d) $l = \frac{FL}{\pi r^2 Y} \therefore l \propto \frac{1}{r^2}$ (*F*,*L* and *Y* are constant)

$\frac{l_2}{l_1} = \left(\frac{r_1}{r_2}\right)^2 = (2)^2 \Rightarrow l_2 = 4l_1 = 4\times2 = 8\ mm.$

98. (b) Let *L* is the original length of the wire and *K* is force constant of wire.

Final length = initial length + elongation

$L' = L + \frac{F}{K}$

For first condition $a = L + \frac{4}{K}$

For second condition $b = L + \frac{5}{K}$ …(ii)

By solving (i) and (ii) equation we get

$L = 5a - 4b$ and $K = \frac{1}{b-a}$

Now when the longitudinal tension is 9*N*, length of the string = $L + \frac{9}{K} = 5a - 4b + 9(b-a)$

$= 5b - 4a$.

99. (a)

100. (b)

101. (b) $K = Yr_0 = 20\times10^{10}\times3\times10^{-10} = 60\ N/m$

$= 6\times10^{-9}\ N/Å$

102. (a) $l = \frac{FL}{AY} = \frac{4.8\times10^3\times4}{1.2\times10^{-4}\times1.2\times10^{11}} = 1.33\ mm$

103. (b)

104. (d) $Y = \frac{\text{Stress}}{\text{Strain}} = \text{Constant}$

It depends only on nature of material.

105. (b) $2\pi\sqrt{\frac{m}{k}} = 0.6$ …(i) and $2\pi\sqrt{\frac{m+m'}{k}} = 0.7$ …(ii)

Dividing (ii) by (i) we get $\left(\frac{7}{6}\right)^2 = \frac{m+m'}{m} = \frac{49}{36}$

$\frac{m+m'}{m} - 1 = \frac{49}{36} - 1 \Rightarrow \frac{m'}{m} = \frac{13}{36} \Rightarrow m' = \frac{13m}{36}$

Also $\frac{k}{m} = \frac{4\pi^2}{(0.6)^2}$

Desired extension $= \frac{m'g}{k} = \frac{13}{36}\times\frac{mg}{k}$

$= \frac{13}{36}\times10\times\frac{0.36}{4\pi^2} \approx 3.5\ cm$

106. (a) $Y = \frac{F/A}{\text{Strain}} \Rightarrow \text{strain} = \frac{F}{AY}$

107. (d) $Y = \frac{k}{r_0} = \frac{7}{3\times10^{-10}} = 2.33\times10^{10}\ N/m^2$

108. (d) $F = Y\times A\times\frac{l}{L} \Rightarrow F \propto \frac{r^2}{L}$ (*Y* and *l* are constant)

$\frac{F_A}{F_B} = \left(\frac{r_A}{r_B}\right)^2\times\left(\frac{L_B}{L_A}\right) = \left(\frac{2}{1}\right)^2\times\left(\frac{2}{1}\right) = \frac{8}{1}$

109. (c)

110. (d) When the length of wire is doubled then $l = L$ and strain = 1 ∴ *Y* = strain $= \frac{F}{A}$

∴ Force = *Y* × *A* $= 2\times10^{11}\times0.1\times10^{-4}$ …(i) $= 2\times10^6\ N$

111. (c) Potential energy stored in the rubber cord catapult will be converted into kinetic energy of mass.

$\frac{1}{2}mv^2 = \frac{1}{2}\frac{YAl^2}{L} \Rightarrow v = \sqrt{\frac{YAl^2}{mL}}$

$= \sqrt{\frac{5\times10^8\times25\times10^{-6}\times(5\times10^{-2})^2}{5\times10^{-3}\times10\times10^{-2}}} = 250\ m/s$

112. (c)

113. (c)

114. (d)

115. (d) Breaking force ∝ r^2

If diameter becomes double then breaking force will become four times *i.e.* 1000 × 4 = 4000 *N*

116. (b)

117. (d) $l = \frac{FL}{AY} = \frac{FL^2}{(AL)Y} = \frac{FL^2}{VY}$

∴ $l \propto L^2$ If volume of the wire remains constant

$\frac{l_2}{l_1} = \left(\frac{L_2}{L_1}\right)^2 = \left(\frac{8}{2}\right)^2 = 16$

$\therefore l_2 = 16 \times l_1 = 16 \times 2 = 32mm = 3.2cm$

118. (a) $l = \frac{FL}{AY} \therefore l \propto \frac{1}{A}$ (*F*,*L* and *Y* are constant]

$\frac{l_2}{l_1} = \frac{A_1}{A_2} = \frac{4}{8} = \frac{1}{2} \Rightarrow l_2 = \frac{l_1}{2} = \frac{0.1}{2} = 0.05mm$

119. (c) $L = \frac{p}{dg} = \frac{10^6}{3 \times 10^3 \times 10} = \frac{100}{3} = 33.3m$

120. (a) $l = \frac{L^2 dg}{2Y} = \frac{(10)^2 \times 1500 \times 10}{2 \times 5 \times 10^8} = 15 \times 10^{-4} m$

121. (a) $Y = 3K(1 - 2\sigma),\ Y = 2\eta(1 + \sigma)$

For $Y = 0$, we get $1 - 2\sigma = 0$, also $1 + \sigma = 0$

$\Rightarrow \sigma$ lies between $\frac{1}{2}$ and -1.

122. (a) Value of Poisson's ratio lie in range of -1 to $\frac{1}{2}$

123. (b) We know that $\frac{dV}{V} = (1 + 2\sigma)\frac{dL}{L}$

If $\sigma = -\frac{1}{2}$ then $\frac{dV}{V} = 0$

i.e. there is no change in volume.

124. (b) $\frac{dV}{V} = (1 + 2\sigma)\frac{dL}{L}$

$\frac{dV}{V} = 2 \times 2 \times 10^{-3} = 4 \times 10^{-3}$ $\left[\because \sigma = 0.5 = \frac{1}{2}\right]$

$\therefore$ Percentage change in volume = $4 \times 10^{-1} = 0.4\%$

125. (b) $l = \frac{FL}{\pi r^2 Y} \therefore l \propto \frac{L}{r^2}$

Ratio of $\frac{L}{r^2}$ is maximum for wire in option (b).

Bulk Modulus

1. (c) Isothermal elasticity $K_i = P$

2. (c) Adiabatic elasticity $K_a = \gamma P$

3. (b) Ratio of adiabatic and isothermal elasticities

$\frac{E\phi}{E\theta} = \frac{\gamma P}{P} = \gamma = \frac{C_p}{C_v}$

4. (d)

5. (b) For triatomic gas $\gamma = \frac{4}{3}$

6. (d) From the ideal gas equation $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\frac{E_2}{E_1} = \frac{P_2}{P_1} = \frac{V_1}{V_2} \times \frac{T_2}{T_1} = \left(\frac{1}{4}\right) \times \left(\frac{400}{300}\right) = \frac{1}{3} \Rightarrow E_2 = \frac{E_1}{3}$

i.e. elasticity will become $\frac{1}{3}$ times.

7. (a) $C = \frac{1}{K} = \frac{\Delta V/V}{\Delta P} \Rightarrow \Delta V = C \times \Delta P \times V$

$= 4 \times 10^{-5} \times 100 \times 100 = 0.4cc$

8. (d) $K = \frac{\Delta P}{\Delta V/V} = \frac{h\rho g}{\Delta V/V} = \frac{200 \times 10^3 \times 10}{0.1/100} = 2 \times 10^9$

9. (c) $\frac{1}{K}$ = compressibility $= \left(\frac{-\Delta V/V}{\Delta P}\right)$

10. (c) $K = \frac{100}{0.01/100} = 10^6 atm = 10^{11}\ N/m^2 = 10^{12}\ dyne/cm^2$

11. (b)

12. (c)

13. (d) If side of the cube is L then $V = L^3 \Rightarrow \frac{dV}{V} = 3\frac{dL}{L}$

$\therefore$ % change in volume = 3 × (% change in length)

= 3 × 1% = 3% $\therefore$ Bulk strain $\frac{\Delta V}{V} = 0.03$

14. (a) $B = \frac{\Delta p}{\Delta V/V} = \frac{h\rho g}{0.1/100} = \frac{200 \times 10^3 \times 9.8}{1/1000}$

$= 19.6 \times 10^8\ N/m^2$

15. (c) Isothermal elasticity $K_i = P = 1 atm = 1.013 \times 10^5\ N/m^2$

16. (b)

17. (c) Isothermal bulk modulus = Pressure of gas

18. (c)

19. (a) If coefficient of volume expansion is α and rise in temperature is $\Delta\theta$ then $\Delta V = V\alpha\Delta\theta \Rightarrow \frac{\Delta V}{V} = \alpha\Delta\theta$

Volume elasticity $\beta = \frac{P}{\Delta V/V} = \frac{P}{\alpha\Delta\theta} \Rightarrow \Delta\theta = \frac{P}{\alpha\beta}$

20. (d) $K = \frac{\Delta p}{\Delta V/V} = \frac{(1.165 - 1.01) \times 10^5}{10/100} = \frac{0.155 \times 10^5}{1/10}$

$= 1.55 \times 10^5\ pa$

21. (b) $B = \frac{\Delta p}{\Delta V/V} \Rightarrow \frac{1}{B} \propto \frac{\Delta V}{V}$ [Δp = constant]

Rigidity Modulus

1. (b)

2. (d) Modulus of rigidity is the property of material.

3. (c) $Y = 2\eta(1 + \sigma)$

4. (d) $Y = 2\eta(1+\sigma) \Rightarrow \sigma = \frac{0.5Y - \eta}{\eta}$

5. (c) Twisting couple $C = \frac{\pi\eta r^4\theta}{2l}$

If material and length of the wires A and B are equal and equal twisting couple are applied then

$\theta \propto \frac{1}{r^4}$ $\therefore$ $\frac{\theta_1}{\theta_2} = \left(\frac{r_2}{r_1}\right)^4$

6. (a) A small part of the spring bear tangential stress, causing straining strain.

7. (a) $Y = 2\eta(1+\sigma)$

For no transverse strain ($\sigma = 0$)

$Y = 2\eta \Rightarrow \eta = \frac{Y}{2} = 3\times10^{12}\ N/m^2$

8. (b) $Y = 2\eta(1+\sigma)$ $\Rightarrow$ $3\eta = 2\eta(1+\sigma) \Rightarrow \sigma = \frac{3}{2} - 1 = \frac{1}{2}$

Now substituting the value of σ in the following expression.

$Y = 3K(1-2\sigma)$ $\Rightarrow$ $K = \frac{Y}{3(1-2\sigma)} = \infty$

9. (c)

10. (d) $Y = 2\eta(1+\sigma)$

$2.4\eta = 2\eta(1+\sigma) \Rightarrow 1.2 = 1+\sigma \Rightarrow \sigma = 0.2$

11. (d) Shearing strain $\phi = \frac{x}{L} = \frac{0.02cm}{10cm}$ $\therefore$ $\phi = 0.002$

12. (b)

13. (d) There will be both shear stress and normal stress.

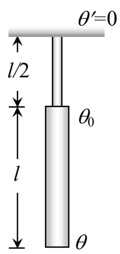
14. (b) Angle of shear $\phi = \frac{r\theta}{L} = \frac{4\times10^{-1}}{100}\times30^o = 0.12^o$

15. (c) For twisting, Angle of shear $\phi \propto \frac{1}{L}$

i.e. if L is more then ϕ will be small.

16. (b) $r\theta = L\phi \Rightarrow 10^{-2}\times0.8 = 2\times\phi \Rightarrow \phi = 0.004$

17. (d) $\tau = C.\theta = \frac{\pi\eta r^4\theta}{2L} =$ Constant



$\Rightarrow \frac{\pi\eta r^4(\theta-\theta_0)}{2l} = \frac{\pi\eta(r/2)^4(\theta_0-\theta')}{2(l/2)}$

$\Rightarrow \frac{(\theta-\theta_0)}{2} = \frac{\theta_0}{16} \Rightarrow \theta_0 = \frac{8}{9}\theta$

18. (c)

Work Done in Stretching a Wire

1. (d) $U = \frac{1}{2}\left(\frac{YA}{L}\right)l^2$ $\therefore$ $U \propto l^2$

$\frac{U_2}{U_1} = \left(\frac{l_2}{l_1}\right)^2 = \left(\frac{10}{2}\right)^2 = 25 \Rightarrow U_2 = 25U_1$

i.e. potential energy of the spring will be 25 V

2. (b)

3. (c) Work done = $\frac{1}{2}Fl = \frac{Mgl}{2}$

4. (a) $W = \frac{1}{2}Fl$ $\therefore$ $W \propto l$ (F is constant)

$\therefore$ $\frac{W_1}{W_2} = \frac{l_1}{l_2} = \frac{l}{2l} = \frac{1}{2}$

5. (b) $W = \frac{1}{2}\times F\times l = \frac{1}{2}mgl$

$= \frac{1}{2}\times10\times10\times1\times10^{-1} = 0.05\ J$

6. (c) $K = \frac{F}{l}$ and $W = \frac{1}{2}Fl = \frac{1}{2}Kl\times l = \frac{1}{2}Kl^2$

7. (d) Due to tension, intermolecular distance between atoms is increased and therefore potential energy of the wire is increased and with the removal of force interatomic distance is reduced and so is the potential energy. This change in potential energy appears as heat in the wire and thereby increases the temperature.

8. (c) Due to increase in intermolecular distance.

9. (b)

10. (b) $U = \frac{1}{2}\times\frac{(\text{stress})^2}{Y}\times\text{volume} = \frac{1}{2}\times\frac{F^2\times A\times L}{A^2\times Y}$

$= \frac{1}{2}\times\frac{F^2L}{AY} = \frac{1}{2}\times\frac{(50)^2\times0.2}{1\times10^{-4}\times1\times10^{11}} = 2.5\times10^{-5}\ J$

11. (c) Work done in stretching a wire

$W = \frac{1}{2}Fl = \frac{1}{2}\times10\times0.5\times10^{-3} = 2.5\times10^{-3}\ J$

Work done to displace it through 1.5 *mm*

$W = F\times l = 5\times10^{-3}\ J$

The ratio of above two work = 1 : 2

12. (a) Increase in energy $= \frac{1}{2}\times20\times1\times10^{-3} = 0.01J$

13. (d) Ratio of work done = $\frac{1/2Fl}{Fl} = \frac{1}{2}$

14. (a) Energy per unit volume $= \frac{1}{2}\times\text{Y}\times(\text{strain})^2$

$\therefore \text{strain} = \sqrt{\frac{2E}{Y}}$

15. (a) Energy per unit volume = $\frac{(\text{stress})^2}{2Y}$

$\frac{E_1}{E_2} = \frac{Y_2}{Y_1}$ (Stress is constant) $\therefore$ $\frac{E_1}{E_2} = \frac{3}{2}$

16. (a) Energy = $\frac{1}{2}Fl = \frac{1}{2}\times F\times\left(\frac{FL}{AY}\right) = \frac{1}{2}\times\frac{F^2L}{AY}$

$= \frac{1}{2}\times\frac{(50)^2\times 20\times 10^{-2}}{2\times 10^{-4}\times 1.4\times 10^{11}} = 8.57\times 10^{-6}\,J$

17. (b) $U = \frac{F^2}{2K} = \frac{T^2}{2K}$

18. (a) Energy stored per unit volume = $\frac{1}{2}\left(\frac{F}{A}\right)\left(\frac{l}{L}\right) = \frac{Fl}{2AL}$

19. (c) $U = \frac{1}{2}\times\frac{YAl^2}{L} = \frac{1}{2}\times\frac{2\times 10^{11}\times 3\times 10^{-6}\times(1\times 10^{-3})^2}{4}$

$= 0.075\,J$

20. (d) At extension l_1, the stored energy $= \frac{1}{2}Kl_1^2$

At extension l_2, the stored energy $= \frac{1}{2}Kl_2^2$

Work done in increasing its extension from l_1 to l_2

$= \frac{1}{2}K(l_2^2 - l_1^2)$

21. (b) $K = \frac{F}{x} = \frac{40}{2\times 10^{-2}} = 0.2\,N/m$

Work done $= \frac{1}{2}Kx^2 = \frac{1}{2}\times(0.2)\times(0.05)^2 = 2.5\,J$

22. (c)

23. (c)

24. (c) $W = \frac{YAl^2}{2L} = \frac{2\times 10^{10}\times 10^{-6}\times(10^{-3})^2}{2\times 50\times 10^{-2}} = 2\times 10^{-2}\,J$

25. (b) $U = \frac{1}{2}\times Y\times(\text{Strain})^2 = \frac{1}{2}\times 9\times 10^{11}\times\left(\frac{1}{100}\right)^2$

$= 4.5\times 10^7\,J$

26. (a) $W = \frac{1}{2}Fl = \frac{1}{2}\times Mg\times l = \frac{1}{2}\times 5\times 10\times 3 = 75\,J$

27. (b)

28. (a)

29. (a) $U = \frac{1}{2}\times F\times l = \frac{1}{2}\times 200\times 10^{-3} = 0.1\,J$

30. (b) $U = \frac{1}{2}Fl = \frac{F^2L}{2AY}$. $U \propto \frac{L}{r^2}$ (F and Y are constant)

$\therefore \frac{U_A}{U_B} = \left(\frac{L_A}{L_B}\right)\times\left(\frac{r_A}{r_B}\right)^2 = (3)\times\left(\frac{1}{2}\right)^2 = \frac{3}{4}$

Critical Thinking Questions

1. (b)

2. (a) $L = \frac{P}{dg} = \frac{6}{3\times 10^3\times 10} = \frac{100}{3} = 34\,m$

3. (c) Thermal stress = $Y\alpha\Delta\theta$.

If thermal stress and rise in temperature are equal then $Y \propto \frac{1}{\alpha} \Rightarrow \frac{Y_1}{Y_2} = \frac{\alpha_2}{\alpha_1} = \frac{3}{2}$

4. (a) Speed of sound in a stretched string $v = \sqrt{\frac{T}{\mu}}$ …(i)

Where T is the tension in the string and μ is mass per unit length.

According to Hooke's law, $F \propto x\ \therefore\ T \propto x$

From (i) and (ii) $v \propto \sqrt{x}\ \therefore\ v' = \sqrt{1.5}\,v = 1.22\,v$

5. (c) Total force at height $3L/4$ from its lower end

= Weight suspended + Weight of 3/4 of the chain

$= W_1 + (3W/4)$

Hence stress $= \frac{W_1 + (3W/4)}{S}$

6. (d) $l = \frac{FL}{AY}\ \therefore\ l \propto \frac{1}{r^2}$ (F, L and Y are constant)

$\frac{l_1}{l_2} = \left(\frac{r_2}{r_1}\right)^2 = (2)^2 = 4$

7. (c) Restoring force is zero at mean position

$F = -Kx + F_0 \Rightarrow 0 = -Kx + F_0 \Rightarrow x = \frac{F_0}{K}$

i.e. the particle will oscillate about $x = \frac{F_0}{K}$

8. (b)

Graphical Questions

1. (d) $T = 2\pi\sqrt{\frac{M}{K}} \Rightarrow T^2 \propto M$

If we draw a graph between T^2 and M then it will be straight line.

and for $M = 0$, $T^2 = 0$

i.e. the graph should pass through the origin.

but from the it is not reflected it means the mass of pan was neglected.

2. (a) In the region OA, stress ∝ strain *i.e.* Hooke's law hold good.

3. (c)

4. (c)

5. (d) As stress is shown on x-axis and strain on y-axis

So we can say that $Y = \cot\theta = \frac{1}{\tan\theta} = \frac{1}{\text{slope}}$

So elasticity of wire P is minimum and of wire R is maximum

6. (a) Area of hysterisis loop gives the energy loss in the process of stretching and unstretching of rubber band and this loss will appear in the form of heating.

7. (d) $\frac{Y_A}{Y_B} = \frac{\tan\theta_A}{\tan\theta_B} = \frac{\tan 60}{\tan 30} = \frac{\sqrt{3}}{1/\sqrt{3}} = 3 \Rightarrow Y_A = 3Y_B$

8. (a) $l = \frac{FL}{AY}$ $\therefore$ $l \propto \frac{1}{r^2}$ (*Y, L* and *F* are constant)

i.e. for the same load, thickest wire will show minimum elongation. So graph D represent the thickest wire.

9. (a) From the graph $l = 10^{-4}\, m,\, F = 20\, N$

$$A = 10^{-6}\, m^2,\, L = 1 m$$

$$\therefore\ Y = \frac{FL}{Al} = \frac{20\times 1}{10^{-6}\times 10^{-4}} = 20\times 10^{10} = 2\times 10^{11}\, N/m^2$$

10. (b) At point b, yielding of material starts.

11. (c) Graph between applied force and extension will be straight line because in elastic range,

Applied force $\propto$ extension

but the graph between extension and stored elastic energy will be parabolic in nature

As $U = 1/2\, kx^2$ or $U \propto x^2$.

12. (b) $F = -\left(\frac{dU}{dx}\right)$.

In the region BC slope of the graph is positive

$\therefore$ F = negative *i.e.* force is attractive in nature

In the region AB slope of the graph is negative

$\therefore$ F = positive *i.e.* force is repulsive in nature

13. (b) Force constant, K = tan 30° = $1/\sqrt{3}$

14. (b) In ductile materials, yield point exist while in Brittle material, failure would occur without yielding.

15. (d) Young's modulus is defined only in elastic region and

$$Y = \frac{\text{Stress}}{\text{Strain}} = \frac{8\times 10^7}{4\times 10^{-4}} = 2\times 10^{11}\ N/m^2$$

16. (a) Elasticity of wire decreases at high temperature *i.e.* at higher temperature slope of graph will be less.

So we can say that $T_1 > T_2$

17. (c)

18. (d) Attraction will be minimum when the distance between the molecule is maximum.

Attraction will be maximum at that point where the positive slope is maximum because $F = -\frac{dU}{dx}$

19. (c) $Y = \tan\theta$. According to figure $\theta_A > \theta_B > \theta_C$

i.e. $\tan\theta_A > \tan\theta_B > \tan\theta_C$

or $Y_A > Y_B > Y_C$

$\therefore$ *A, B,* and *C* graph are for steel, brass and rubber respectively.

Assertion and Reason

1. (a) Because, the stretching of coil simply changes its shape without any change in the length of the wire used in coil. Due to which shear modulus of elasticity is involved.

2. (e) When a spring balance has been used for a long time, the spring in the balance fatigued and there is loss of strength of the spring. In such a case, the extension in the spring is more for a given load and hence the balance gives wrong readings.

3. (a) Elasticity is a measure of tendency of the body to regain its original configuration. As steel is deformed less than rubber therefore steel is more elastic than rubber.

4. (d) In a glassy solid (*i.e.*, amorphous solid) the various bonds between the atoms or ions or molecules of a solid are not equally strong. Different bonds are broken at different temperatures. Hence there is no sharp melting point for a glassy solid.

5. (a)

6. (a) Bulk modulus of elasticity measures how good the body is to regain its original volume on being compressed. Therefore, it represents incompressibility of the material.

$K = \frac{-PV}{\Delta V}$ where P is increase in pressure, ΔV is change in volume.

7. (c) Strain is the ratio of change in dimensions of the body to the original dimensions. Because this is a ratio, therefore it is dimensionless quantity.

8. (a) A bridge during its use undergoes alternating strains for a large number of times each day, depending upon the movement of vehicles on it when a bridge is used for long time, it losses its elastic strength. Due to which the amount of strain in the bridge for a given stress will become large and ultimately, the bridge may collapse. This may not happen, if the bridges are declared unsafe after long use.

9. (d) Ivory is more elastic than wet-clay. Hence the ball of ivory will rise to a greater height. In fact the ball of wet-clay will not rise at all, it will be somewhat flattened permanently.

10. (a) Young's modulus of a material, $Y = \frac{\text{Stress}}{\text{Strain}}$

Here, stress $= \frac{\text{Restoringforce}}{\text{Area}}$.

As restoring force is zero $\therefore$ $Y = 0$.

11. (a) Work done $= \frac{1}{2} \times \text{Stress} \times \text{Strain} = \frac{1}{2} \times Y \times (\text{Strain})^2$.

Since, elasticity of steel is more than copper, hence more work has to be done in order to stretch the steel.

12. (b) Stress is defined as internal force (restoring force) per unit area of a body. Also, rubber is less elastic than steel, because restoring force is less for rubber than steel.