ELASTICITY

PREVIOUS EAMCET QUESTIONS

ENGINEERING

1. If the ratio of lengths, radii and young's moduli of steel and brass wires shown in the figure are a, b and c respectively, the ratio between the increase in lengths of brass and steel wires would be: **[2009 E]**

1) $\frac{b^2a}{2c}$ 2) $\frac{bc}{2a^2}$ 3) $\frac{ba^2}{2c}$ 4) $\frac{b^2c}{2a}$

Ans : 4

Sol: $\frac{e_{Brass}}{e_{steel}} = \frac{T_B}{T_s} \times \frac{L_B}{L_S} \times \frac{r_s^2}{r_B^2} \times \frac{y_s}{y_B}$

2. A mass of 6.5 kg is hanging from the end of a 60 cm long steel wire ($Y = 2 \times 10^{11}$ Pa) with area of cross-section 0.05 cm^2. When it is revolving in a vertical circle it has an angular velocity of 2 revolutions per second, at the bottom of the circle. Approximate elongation of the wire (in meters) when the mass is at its lowest point of the trajectory is **(2008 E)**

1) 8×10^{-4} 2) 4×10^{-4} 3) 8×10^{-5} 4) 4×10^{-5}

Ans : 1

Sol: Tension in the string on crossing the mean position

$$T = mg + \frac{mv^2}{r} = mg + \frac{mv^2}{l}$$

But $V = \sqrt{2gl\left(1-\cos\theta\right)}$

Given $\theta = 90^0 \Rightarrow V = \sqrt{2gl}$

$$\therefore T = mg + \frac{m}{l} \times 2gl = 3mg$$

Youngs modulus $Y = \frac{FL}{Ae} \Rightarrow \frac{e}{L} = \frac{F}{Ay}$

$$= \frac{3 \times 1 \times 1}{3 \times 10^{-6} \times 10^{11}} = 10^{-4}$$

3. When a wire of length 10 m is subjected to a force of 100 N along its length, the lateral strain produced is 0.01×10^{-3} m. The poisson's ratio was found to be 0.4. If the area of cross-section of wire is 0.025 m^2, its young's modulus is **(2007 E)**

1) 1.6×10^8 N/m^2 2) 2.5×10^{10} N/m^2 3) 1.25×10^{11} N/m^2 4) 16×10^9 N/m^2

Ans : 1

Sol: Poisson's ration = $\sigma = \frac{-\frac{\Delta r}{r}}{\frac{\Delta l}{l}} = \frac{lateral\ strain}{longitudinal\ strain}$

$$\therefore \frac{\Delta l}{l} = \frac{\frac{\Delta r}{r}}{\sigma}$$

$$= \frac{10^{-5}}{0.4} = 25\times10^{-6}$$

$$Y = \frac{Fl}{Ae} = \frac{F}{A\left(\frac{e}{l}\right)} = \frac{100}{25\times10^{-3}\times25\times10^{-6}}$$

$$\therefore y = 1.6\times10^{18}\,Nm^{-2}$$

4. **Assertion (A) :** Ductile metals are used to prepare thin wires.

Reason (R) : In the stress-strain curve of ductile metals, the length between the points representing elastic limit and breaking point is very small. **(2006 E)**

1) Both **(A)** and **(R)** are true and **(R)** is the correct explanation of **(A)**

2) Both **(A)** and **(R)** are true but **(R)** is not the correct explanation of **(A)**

3) **(A)** is true but **(R)** is false

4) **(A)** is false but **(R)** is true

Ans : 3

Sol: Ductile metals can be drawn into thin wires. Therefore the length between the points representing elastic limit and breaking point is large

5. The radii and young's modulus of two uniform wires A & B are in the ratio 2:1 and 1:2 respectively. Both the wires are subjected to the same longitudinal force. If increase in the length of wire A is 1% . Then the increase in length wire B is (2005 E)

1) 1 2) 1.5 3) 2 4) 3

Ans : 3

Sol: $\frac{r_A}{r_B} = \frac{2}{1}, \frac{Y_A}{Y_B} = \frac{1}{2}, F_A = F_B$

$$\frac{e_A}{l_A}\times 100 = 1 \Rightarrow \frac{e_A}{l_A} = \frac{1}{100}$$

$$y = \frac{FL}{Ae} = \frac{F}{A\left(\frac{e}{L}\right)} \Rightarrow \frac{e}{L} = \frac{F}{Ay} = \frac{F}{\pi r^2 y}$$

$\therefore$ from

$$\Rightarrow \frac{\left(\frac{e_B}{L_B}\right)}{\left(\frac{e_A}{L_A}\right)} = \left(\frac{r_A}{r_B}\right)^2 \times \left(\frac{y_A}{y_B}\right)$$

$$\Rightarrow \frac{\left(\frac{e_B}{L_B}\right)}{\frac{1}{100}} = \left(\frac{2}{1}\right)^2 \times \frac{1}{2}$$

Percentage increase in length of the wire B $\Rightarrow \frac{e_B}{L_B}\times 100 = \frac{2}{100}\times 100 = 2$

6. A metallic ring of radius 'r' cross sectional area 'A' is fitted in to a wooden circular disk of radius 'R' (R>r). If the Young's modulus of the material of the ring is 'Y', the force with which the metal ring expands is : (M-2004)

1) $\frac{AYR}{r}$ 2) $\frac{AY(R-r)}{r}$ 3) $\frac{Y(R-r)}{Ar}$ 4) $\frac{YR}{Ar}$ 2004

Ans : 1

Sol: Young's modulus of elasticity

$$y = \frac{FL}{Ae}$$

$\therefore$ Force = $\frac{yAe}{L}$

But $e = 2\pi R - 2\pi r = 2\pi\left[R - r\right]$

$$\therefore F = \frac{yA2\pi\left(R-r\right)}{2\pi r} = \frac{Ay\left(R-r\right)}{r}$$

7. Bulk modulus of water is 2 x 10^9 N/m^2. The pressure required to increase the density of water by 0.1% in N/m^2 is : (E-2003)

1) 2 x 10^9 2) 2 x 10^8 3) 2 x10^6 4) 2 x 10^4

2003

Ans : 3

Sol: Given $\frac{\Delta V}{V}\times 100 = 0.1 \Rightarrow \frac{\Delta V}{V} = 10^{-3}$

Bulk modulus (K) = $\frac{Bulk\ stress}{Bulk\ strain} = \frac{p}{\left(\frac{\Delta V}{V}\right)}$

$\Rightarrow P = K\left(\frac{\Delta V}{V}\right) = 2\times 10^{9}\times 10^{-3}$

= 2×10^{6} Nm^{-2}

8. The Poisson's ratio of a material is 0.4. If a force is applied to a wire of this material, there is a decrease of cross-sectional area by 2%. The percentage increase in its length is : (E 2002)

1) 3% 2) 2.5% 3) 1% 4) 0.5%

Ans : 1

Sol: Poisson's ration $\sigma = \frac{Lateral\ strain}{longitudinal\ strain} = \frac{-\frac{\Delta r}{r}}{\frac{\Delta l}{l}}$

Given $\frac{dA}{A} = 2\%$ but $\frac{dA}{A} = 2\times\frac{dr}{r} \Rightarrow \frac{dr}{r} = 1\%$

$\therefore \frac{dl}{l} = \frac{dr/r}{\sigma} = \frac{1}{0.4} = 2.5\%$

9. The length of an elastic string is 'a' metres when the longitudinal tension is 4N and 'b' meters when the longitudinal tension is 5N. The length of the string in metres when the longitudinal tension is 9 N is

(E-2001)

1) a-b 2) 5b-4a 3) 2b-(1/4)a 4) 4a-3b

Ans : 2

Sol: Let the original length of the string is 'l', when the force is zero

From the relation $y = \frac{FL}{Ae} \Rightarrow F \propto e$

$\therefore$ When the tension is 4N, then the length is a

$\therefore 4 \propto (a-l)$ ……………………….(1)

When the tention is 5N, then the length is b

$\therefore 5 \propto (b-l)$ ……………………….(2)

Dividing (1) & (2)

$$\frac{4}{5}=\frac{a-l}{b-l}\Rightarrow l=5a-4b$$ ………………….(3)

When the tension is 9N, then the length is C

$$\therefore 9\propto\left(c-l\right)$$ ……………………...(4)

Dividing (1) & (4)

$$\frac{9}{4}=\frac{c-l}{a-l}$$

$$\Rightarrow 9a-9l=4c-4l$$

$$\Rightarrow 4c=9a-5l$$

but l = 5a -4b

$$\therefore 4c=9a-25a+20b$$

$$\Rightarrow 4c=20b-16a$$

$$\Rightarrow c=5b-4a$$

10. When a uniform wire of radius r is stretched by a 2 kg weight, the increase in its length is 2.00 mm. If the radius of the wire is r/2 and other conditions remain in the same, increase in its length is

(E-2000)

1) 2.00mm 2) 4.00 mm 3) 6.00 mm 4) 8.00mm

Ans : 4

Sol: From the relation $y=\frac{FL}{Ae}=\frac{FL}{\pi r^2 e}$

$$\Rightarrow e\propto\frac{1}{r^2}\Rightarrow\frac{e_1}{e_2}=\left(\frac{r_2}{r_1}\right)^2$$

= $$\frac{2}{e_2}=\left(\frac{r/2}{r}\right)^2$$

= $$e_2=8mm$$

MEDICAL

11. A light rod of length 100 cms is suspended from the ceiling horizontally by means of two vertical wires of equal lengths tied to the ends of the rod. One of the wires is made of steel and is of area of cross - section $0.1cm_2$. The other wire is k of brass and of area of cross - section $0.2cm_2$. The position from the steel wire

along the rod at which a load is to be placed to produce equal stresses in both wires is : ($Y_{steel} = 20\ 10^{11}$ dynes/cm^2; $Y_{brass} = 1010^{11}$ dynes /cm^2) (2009 M)

1) 100/3cm 2)200/3 cm 3) 50cm 4) 75cm

Ans : 1

Sol: Given that stress in the wires is equal

$$\therefore \frac{F_1}{A_1} = \frac{F_2}{A_2} \Rightarrow \frac{F_1}{F_2} = \frac{0.1}{0.2} = \frac{1}{2}$$

As the system is in equilibrium, taking moments about 'c'

$$F_1\left(x\right) = F_2\left(100 - x\right)$$

$$\Rightarrow \frac{F_1}{F_2} = \frac{100 - x}{x} = \frac{1}{2}$$

Solving x= $\frac{200}{3} cm$

12. When a wire is subjected to a force along its length, its length increases by 0.4% and its radius decreases by 0.2%. Then the Poisson's ratio of the material of the wire is

1) 0.8 2) 0.5 3) 0.2 4) 0.1

Ans : 2

Sol: Poisson's ration $\sigma = \frac{Lateral\ strain}{\mathrm{lo}ngitudinal\ strain} = \frac{\frac{\Delta r}{r}}{\frac{\Delta l}{l}}$

$$= \frac{\frac{0.2}{100}}{\frac{0.4}{100}} = 0.5$$

13. Two rods of different materials with coefficients of linear thermal expansion α_1, α_2 and Young's moduli Y_1 and Y_2 respectively are fixed between two rigid walls. They are heated to have the same increase in temperature. If the rods do not bend and if $\alpha_1 : \alpha_2 = 2 : 3$, then the thermal stresses developed in the two rods will be equal when $Y_1 : Y_2$ is equal to **(2007 M)**

1) 2 : 3 2) 2 : 5 3) 3 : 2 4) 5 : 2

Ans : 3

Sol: Thermal Stress $\frac{F}{A} = y \propto \Delta t$

As thermal stress is equal

$\therefore y_1\alpha_1\Delta t_1 = y_2\alpha_2\Delta t_2$

$\therefore \frac{y_1}{y_2} = \frac{\alpha_2}{\alpha_1}$ [same rise in temperature]

$\therefore \frac{y_1}{y_2} = \frac{3}{2}$

14. A body subjected to strain several times will not obey Hook's law due to **(2007 M)**

1) Yield point 2) permanent state 3) Elastic fatigue 4) Breaking stress

Ans: 3

Sol: Because of Elastic fatigue the body loses the property of elasticity temporarly.

15. A mass of 6.5 kg is hanging from the end of a 60 cm long steel wire ($Y = 2 \times 10^{11}$ Pa) with area of cross-section 0.05 cm^2. When it is revolving in a vertical circle it has an angular velocity of 2 revolutions per second, at the bottom of the circle. Approximate elongation of the wire (in meters) when the mass is at its lowest point of the trajectory is **(2006 M)**

1) 8×10^{-4} 2) 4×10^{-4} 3) 8×10^{-5} 4) 4×10^{-5}

Ans : 2

Sol: Youngs modulus $y = \frac{FL}{Ae}$

$\therefore$ elongation $(e) = \frac{FL}{Ay}$

But $F = mg + mr\omega^2$

$\therefore e = \frac{(mg + mr\omega^2)L}{Ay}$

Sub the given values $e = 4\times10^{-4} m$

16. Two wires of same material and same diameter have lengths in the ratio 2:5. They are stretched by same force. The ratio of work done in stretching them is **(2005M)**

1) 5 : 2 2) 2 : 5 3) 1:3 4) 3 : 1

Ans : 2

Sol: Work done = $\frac{1}{2}\times Force \times clongation$

But $y = \frac{FL}{Ae} \Rightarrow e = \frac{FL}{Ay}$

$$\therefore w = \frac{1}{2} \times F \times \frac{FL}{Ay} = \frac{F^2 L}{2Ay}$$

$\therefore w \propto l$ [since F,A, Y are same]

$$\Rightarrow \frac{w_1}{w_2} = \frac{l_1}{l_2} = \frac{2}{5}$$

17. The increase in length of a wire on stretching is 0.025%. If its Poisson's ratio is 0.4, then the percentage decrease in the diameter is : **(2004 M)**

1) 0.01 2) 0.02 3) 0.03 4) 0.04

Ans : 1

Sol: Poisson's ratio $\sigma = \frac{lateral\ strain}{longitudinal\ strain}$

$$\therefore lateral\ strain = \sigma \times longitudinal\ strain$$

$= 0.4 \times 0.025$

$= 0.01$

18. Consider the statements A and B, identify the correct answer given below :

(A) : If the volume of a body remains unchanged when subjected to tensile strain, the value of poisson's ratio is 1/2.

(B) : Phosper bronze has low Young's modulus and high rigidity modulus. **(M-2003)**

1) A and B are correct 2) A and B are wrong

3) A is correct and B is wrong 4) A is wrong and B is right

Ans : A is correct

Sol: A) As V = constant

$\therefore \pi r^2 l =$ constant

$\therefore$ from small approximation method

$$2\frac{\Delta r}{r} + \frac{\Delta l}{l} = 0$$

$$\Rightarrow \frac{\Delta l}{l} = \frac{-2\Delta r}{r}$$

$\sigma =$ Poisson's ratio = $\dfrac{\dfrac{-\Delta r}{r}}{\dfrac{\Delta l}{l}}$ $\quad\quad \therefore \sigma = \dfrac{\dfrac{-\Delta r}{r}}{-2\left(\dfrac{\Delta r}{r}\right)} = \dfrac{1}{2}$

A is correct

B) Phosphor bronze has low elongation hence high youngs modulus and low rigidity modulus/

B is wrong

19. Two springs of force constants 1000 N/m and 2000 N/m are stretched by same force. The ratio of their respective potential energies is : **(M-2002)**

1) 2 :1 2) 1 : 2 3) 4 : 1 4) 1 : 4

Ans : 1

Sol: Potential energy

$= \frac{1}{2}Kx^2 = \frac{1}{2}K\left[\frac{F}{K}\right]^2 = \frac{1}{2}\frac{F^2}{K}$

$\Rightarrow P.E \propto \frac{1}{K}$ $\quad\quad \therefore \frac{PE_1}{PE_2} = \frac{K_2}{K_1} = \frac{2000}{1000}$

$\Rightarrow PE_1 : PE_2 = 2:1$

20. A metal cube of side length 8.0 cm has its uper surface displaced with respect to the bottom by 0.10 mm when a tangential force of 4 x 10^9 N is applied at the top with bottom surface fixed. The rigidity modulus of the material of the cube is **(2001 M)**

1) 4 x 10^9 N/m^2 2) 5 x 10^9 N/m^2 3) 8 x 10^9 N/m^2 4) 1x 10^8 N/m^2

Ans : 1

Sol: Rigidity modulus $\eta = \frac{F/A}{Strain}$

Strain = $\frac{0.1\times10^{-3}}{8\times10^{-2}} = \frac{1}{800}$

$\therefore \eta = \frac{4\times10^4}{64\times10^{-2}}\times800$

$= 5\times10^9\ N/m^2$

21. When a tension F is applied, the elongation produced in uniform wire of length 'L', radius 'r' is 'e'. When tension 2 F is applied, the elongation produced in another uniform wire of length '2L' and radius '2r' made of same material is **(2000 M)**

1) 0.5e 2) 1.0e 3) 1.5e 4) 2.0e

Ans : 2

Sol: We know $\frac{e_1}{e_2} = \frac{F_1}{F_2} \times \frac{L_1}{L_2} \times \frac{r_2^2}{r_1^2}$

$$\frac{e_1}{e_2} = \frac{F}{2F} \times \frac{l}{2l} \times \frac{4r^2}{r^2} = 1$$

$$\Rightarrow e_1 = e_2 \quad e_2 = e$$