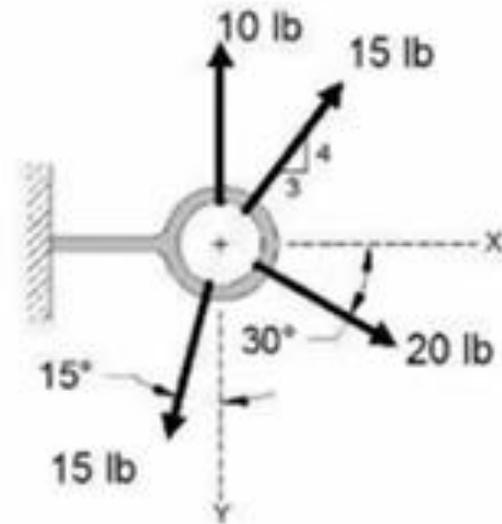# Problem 1
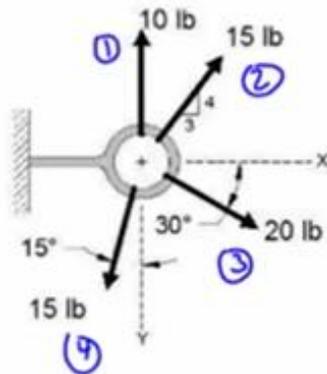
- What is most nearly the magnitude of the resultant of these forces on this eyebolt?

  A. 2.5 lbs
  B. 11.3 lbs
  C. 19.9 lbs
  D. 22.6 lbs

10 lb

15 lb

30°

20 lb

15°

15 lb

x

Problem 1

Problem 1

① $F_x = 0$, $F_y = +10$

② $F_x = \frac{3}{5}(15\,lb) = 9\,lb$, $F_y = \frac{4}{5}(15\,lb) = 12\,lb$

③ $F_x = 20\,lb\,(\cos 30°)$ $F_y = -20\,lb\,(\sin 30°)$
   $= +17.32\,lb$ $= -10\,lb$

④ $F_x = -15\,lb\,(\sin 15°)$ $F_y = -15\,lb\,(\cos 15°)$
   $= -3.88\,lb$ $= -14.49\,lb$

$R_x = \Sigma(F_x) = +22.44\,lb$

$R_y = \Sigma(F_y) = -2.49\,lb$

$\therefore R = \sqrt{R_x^2 + R_y^2} = \sqrt{(22.44\,lb)^2 + (-2.49\,lb)^2} = 22.6\,lb$

$\boxed{D}$

Problem 2

Find the tension, "T," that must be applied to pulley A to lift the 1200 N weight.
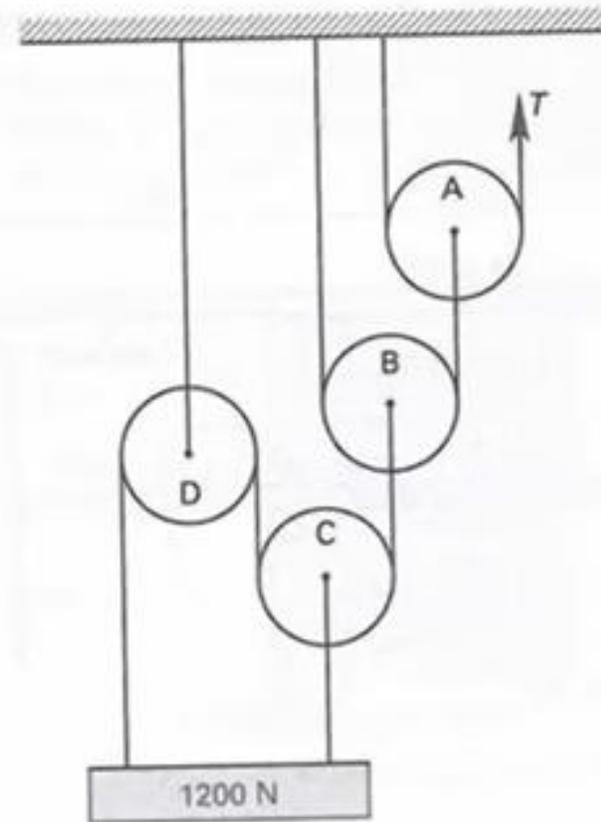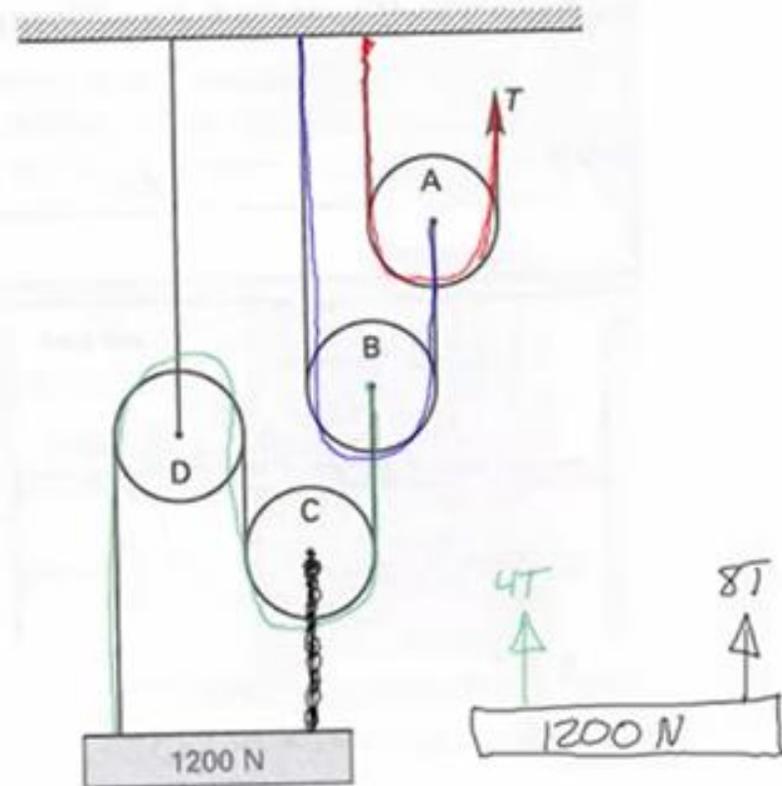
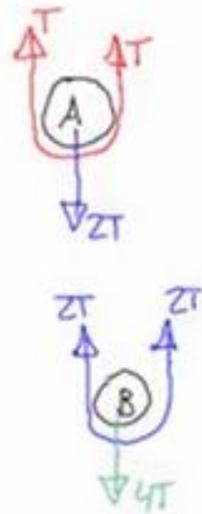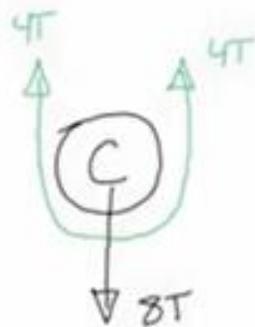A. 100 N
B. 300 N
C. 400 N
D. 600 N

Problem 2

Find the tension, "T," that must be applied to pulley A to lift the 1200 N weight.

A. 100 N
B. 300 N
C. 400 N
D. 600 N

Problem 3

A sign has a mass of 150 kg. The sign is attached to the wall by a pin at point B and is supported by a cable between points A and C. Determine the tension in the cable.
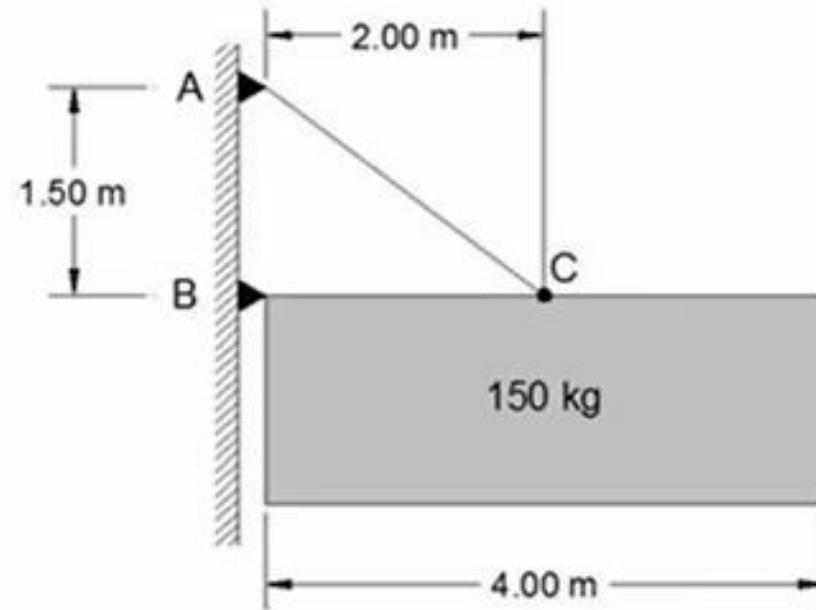
A. 1875 N

B. 2450 N

C. 3750 N

D. 5000 N

Problem 3

A sign has a mass of 150 kg. The sign is attached to the wall by a pin at point B and is supported by a cable between points A and C. Determine the tension in the cable.

A. 1875 N

B. 2450 N

C. 3750 N

D. 5000 N

$$\Sigma M_B = 0$$
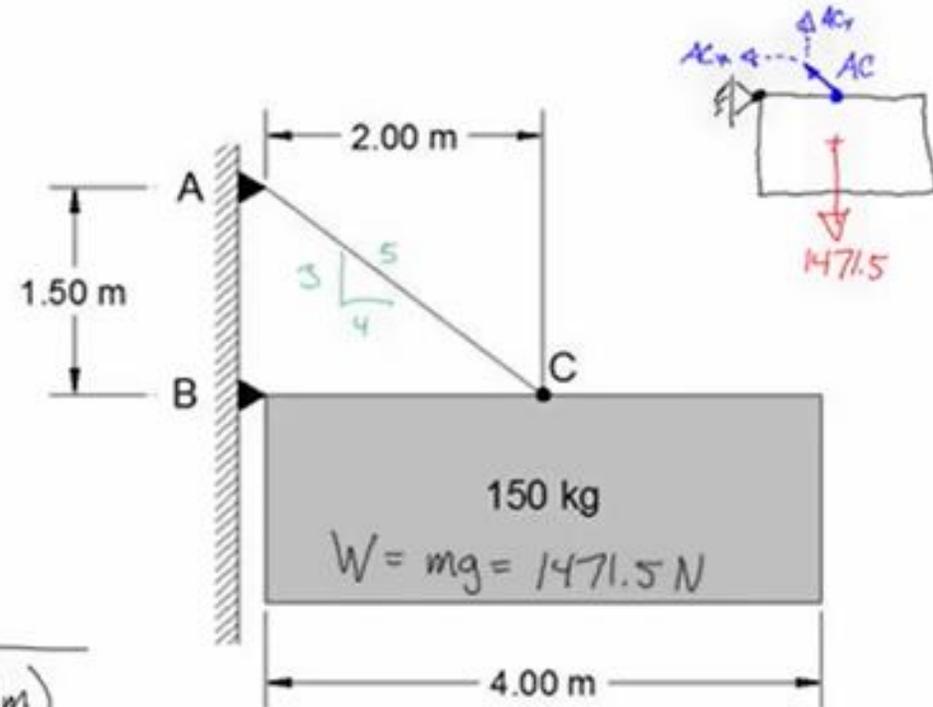
$$\frac{1471.5\,N\,(2m)\,|\,AC_y\,(2m)}{}$$

$$AC_y = 1471.5\,N$$

2.00 m

1.50 m

A

B

C

150 kg

$$W = mg = 1471.5\,N$$

4.00 m

1471.5

$$\therefore \frac{AC_y}{3} = \frac{AC}{5}$$

$$\therefore AC = \frac{5}{3}\,AC_y$$

$$= 2452.5$$

Problem 4

A 100 kg block rests on an incline. The coefficient of static friction between the block and the ramp is 0.2. The mass of the cable is negligible, and the pulley at point C is frictionless. What is the smallest mass of block B that will start the 100 kg block moving up the incline?
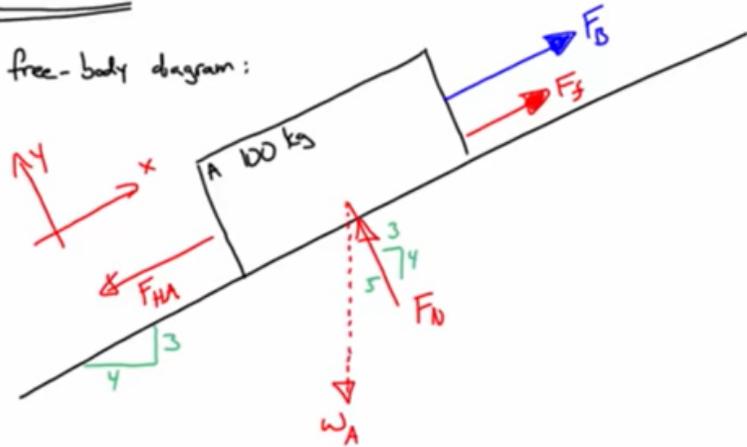
A. 44 kg

B. 65 kg

C. 76 kg

D. 92 kg
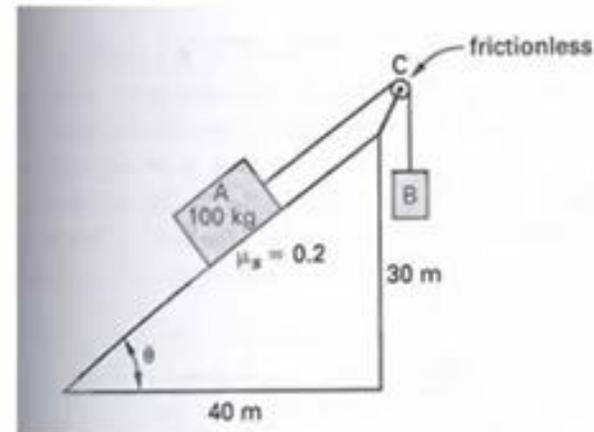
Problem 4

Problem 4

- free-body diagram:

$$w_A = m_A g = 981 \text{ N}$$

$$F_{VA} = F_N = w_A\left(\tfrac{4}{5}\right) = 784.8 \text{ N}$$

$$F_{HA} = w_A\left(\tfrac{3}{5}\right) = 588.6 \text{ N}$$

$$F_f = \mu_s F_N = (0.2)(784.8 \text{ N}) = 156.96 \text{ N}$$

$$\Sigma F_x = 0$$

$F_{HA} = 588.6 \text{N}$	F_B
	$F_f = 156.96 \text{ N}$

$$F_B = 431.64 \text{ N}$$

$$\therefore m_B = \frac{F_B}{g} = 44 \text{ kg}$$ $\boxed{A}$

Correction to Problem 4

- Consider a free-body diagram of block "A":
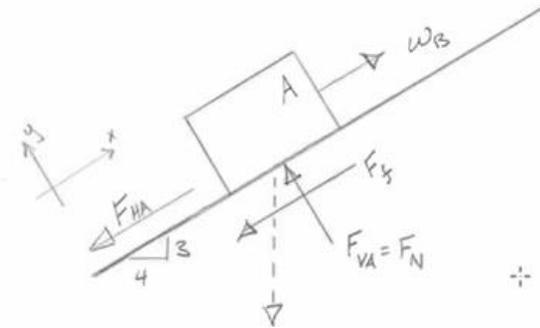
$$w_A = m_A g = 981 \text{ N}$$

$$F_{HA} = w_A\left(\tfrac{3}{5}\right) = 588.6 \text{ N}$$

$$F_{VA} = F_N = w_A\left(\tfrac{4}{5}\right) = 784.8 \text{ N}$$

$$F_f = \mu_s F_N = 156.96 \text{ N}$$

pointing the opposite way!

$$\Sigma F_x = 0$$

F_{HA}	w_B
F_f	

$$w_B = F_{HA} + F_f$$

$$\therefore w_B = 588.6 \text{ N} + 156.96 \text{ N}$$
$$= 745.56 \text{ N}$$

$$m_B = \frac{w_B}{g} = 76 \text{ kg}$$

$\boxed{C}$

Problem 5

What are the x- and y-coordinates of the centroid of the area?

A. 3.40 cm; 5.60 cm

B. 3.50 cm; 5.50 cm

C. 3.93 cm; 4.79 cm

D. 4.00 cm; 5.00 cm

8 cm

5 cm

4 cm diameter

10 cm

7 cm

2 cm by 2 cm

1 cm

1 cm
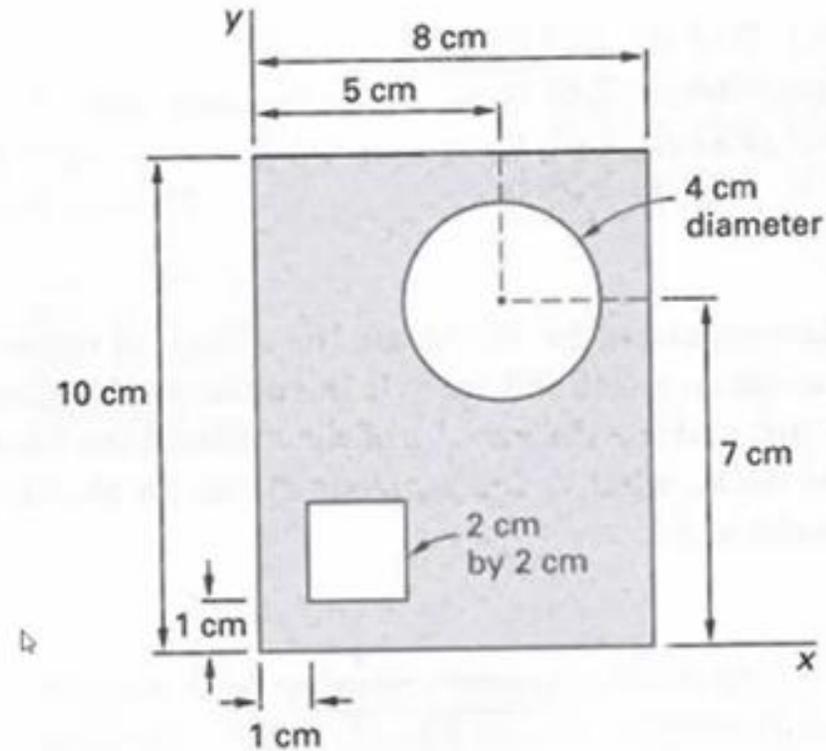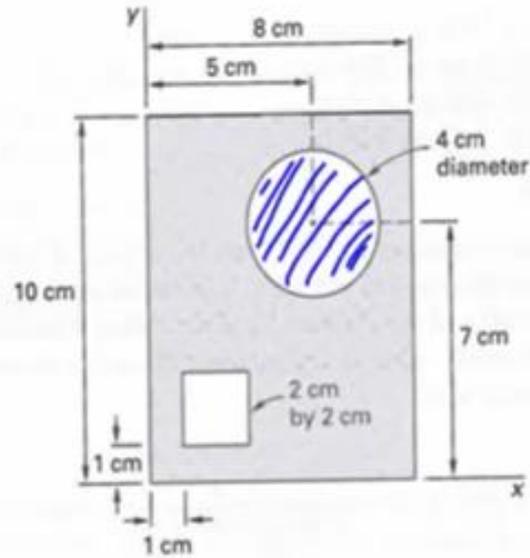
Problem 5

Shape	$A(cm^2)$	$X(cm)$	$Ax(cm^3)$
rect.	80	4	320
Sq. hole	-4	2	-8
Cir. hole	-12.57	5	-62.83
$\Sigma =$	63.43		249.17

$$A = \frac{\pi}{4}d^2 = \frac{\pi}{4}(4cm)^2 = 12.57\ cm^4$$

$$\bar{X} = \frac{\Sigma Ax}{\Sigma A} = \frac{249.17\ cm^3}{63.43\ cm^2} = 3.93\ cm$$

C

Problem 6

A particle starting from rest experienced an acceleration of 3 m/s² for 2 s. The particle then returned to rest in an additional distance of 8 m. Assuming all accelerations were uniform, what was the total time elapsed for the particle's motion?

A. 2.67 s

B. 4.00 s

C. 4.67 s

D. 5.33 s

Problem 6

A particle starting from rest experienced an acceleration of 3 m/s² for 2 s. The particle then returned to rest in an additional distance of 8 m. Assuming all accelerations were uniform, what was the total time elapsed for the particle's motion?

A. 2.67 s

B. 4.00 s

C. 4.67 s

D. 5.33 s

action 1

$V_i = 0 \, m/s$
$V_f = ?$
$a = 3 \, m/s^2$
$t = 2s$

$V_f = V_i + at$
$= 0 \, m/s + (3 \, m/s^2)(2s) = 6 \, m/s$

action 2

$V_i = 6 \, m/s$
$V_f = 0 \, m/s$
$a = ?$
$t = ?$
$X = 8m$

$V_f^2 = V_i^2 + 2ax$

$a = \dfrac{V_f^2 - V_i^2}{2x} = -2.25 \, m/s^2$

$V_f = V_i + at \quad \therefore \quad t = \dfrac{V_f - V_i}{a} = 2.67s$

Problem 7

A 550 kg mass initially at rest is acted upon by a force of $F(t) = 50e^t$, expressed in Newtons. What is the displacement of the mass at t = 4 seconds?

A. 4.51 m
B. 19.5 m
C. 2466 m
D. 3900 m

Problem 7

A 550 kg mass initially at rest is acted upon by a force of $F(t) = 50e^t$, expressed in Newtons. What is the displacement of the mass at $t = 4$ seconds?

$$F = 50e^t \quad , \quad m = 550 \qquad \therefore \quad a = F/m = \frac{50e^t}{550} = \frac{1}{11}e^t$$

A. 4.51 m

B. 19.5 m

C. 2466 m

D. 3900 m

$$a = \frac{dv}{dt} \qquad \therefore \quad v = \int a\,dt = \int \left(\frac{1}{11}e^t\right)dt = \frac{1}{11}e^t + C_1$$

$$@\, t=0, \; v=0 \qquad \therefore \quad v = \frac{1}{11}e^t + C_1$$

$$0 = \frac{1}{11}e^0 + C_1$$

$$0 = \frac{1}{11} + C_1 \qquad \therefore \quad C_1 = -\frac{1}{11}$$

$$V = \frac{1}{11}e^t - \frac{1}{11}$$

$$v = \frac{dx}{dt} \qquad \therefore \quad x = \int v\,dt = \int \left(\frac{1}{11}e^t - \frac{1}{11}\right)dt = \frac{1}{11}e^t - \frac{1}{11}t + C_2$$

$$@\, t=0, \; x=0 \qquad \therefore \quad 0 = \frac{1}{11}e^0 - \frac{1}{11}(0) + C_2$$

$$\therefore \quad C_2 = -\frac{1}{11} \qquad\qquad \therefore \quad x = \frac{1}{11}e^t - \frac{1}{11}t - \frac{1}{11}$$

Problem 8

A 2 kg ball of clay moving at 40 m/s collides with a 5 kg ball of clay moving directly toward the first ball with a velocity of 10 m/s. What is the final velocity if both balls stick together after the collision?

A. 4.29 m/s
B. 23.0 m/s
C. 30.0 m/s
D. 42.9 m/s

Problem 8

A 2 kg ball of clay moving at 40 m/s collides with a 5 kg ball of clay moving directly toward the first ball with a velocity of 10 m/s. What is the final velocity if both balls stick together after the collision?

Conservation of momentum

A. 4.29 m/s

B. 23.0 m/s

C. 30.0 m/s

D. 42.9 m/s

$m_1 = 2 \, kg$

$V_1 = 40 \, m/s$

$m_1 = 5 \, kg$

$V_2 = -10 \, m/s$

$\therefore \; mV_{initial} = m_1 V_1 + m_2 V_2 = 30 \, kg \cdot m/s$

$m_{final} = m_1 + m_2 = 7 \, kg$

$mV_{initial} = mV_{final}$

$\therefore \; V_{final} = \dfrac{mV_{initial}}{m_{final}} = \dfrac{30 \, kg \cdot m/s}{7 kg} = 4.29 \, m/s$

Problem 9

A child keeps a 1 kg toy airplane flying horizontally in a circle by holding onto a 1.5 m long string attached to its wing tip. The string is always in the plane of the circular flight path. If the plane flies at 10 m/s, what is the tension in the string?

A. 7 N

B. 15 N

C. 28 N

D. 67 N

Page 116 – Plane Circular Motion - mv^2/r

Problem 9

A child keeps a 1 kg toy airplane flying horizontally in a circle by holding onto a 1.5 m long string attached to its wing tip. The string is always in the plane of the circular flight path. If the plane flies at 10 m/s, what is the tension in the string?

A. 7 N

B. 15 N

C. 28 N

D. 67 N

$M = 1kg$

$V = 10^m/s$

$r = 15m$

$$F_c = \frac{mv^2}{r} = \frac{(1kg)(10^m/s)^2}{1.5m} = 66.7N$$

Problem 10

A 10 kg axial load is uniformly carried by an aluminum alloy pipe with an outside diameter of 10 cm and an inside diameter of 9.6 cm. The pipe is 1.2 m long. Young's modulus for the aluminum alloy is 75000 MPa. Neglecting the effects of buckling, how much is the pipe compressed?

A. 0.00026 mm
B. 0.0026 mm
C. 0.11 mm
D. 25 mm

Problem 10

Force = N
Length = M
∴ Stress = N/m^2 = P_a
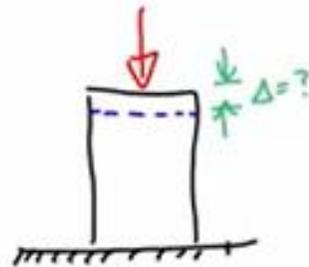
$$\Delta = \frac{PL}{EA}$$

A 10 kg axial load is uniformly carried by an aluminum alloy pipe with an outside diameter of 10 cm and an inside diameter of 9.6 cm. The pipe is 1.2 m long. Young's modulus for the aluminum alloy is 75000 MPa. Neglecting the effects of buckling, how much is the pipe compressed?

A. 0.00026 mm
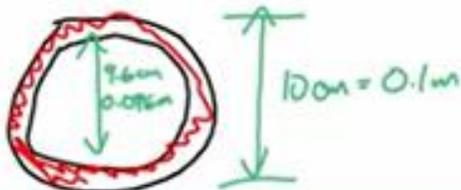B. 0.0026 mm
C. 0.11 mm
D. 25 mm

$$P = (10 \, kg)(9.81 \, m/s^2) = 98.1 \, N$$

$$L = 1.2 \, m$$

$$E = 75000 \, MPa = 75000 \times 10^6 \, P_a$$

$$A = \frac{\pi}{4} d_o^2 - \frac{\pi}{4} d_i^2$$

$$= \frac{\pi}{4}\left[(0.1m)^2 - (0.096m)^2\right] = 6.16 \times 10^{-4} \, m^2$$

$$\therefore \Delta = \frac{(98.1 N)(1.2 m)}{(75000 \times 10^6 \, P_a)(6.16 \times 10^{-4} m^2)} = \frac{2.6 \times 10^{-6} \, m}{2.6 \times 10^{-3} \, mm}$$

$$= 0.0026 \, mm$$

10cm = 0.1m
9.6cm 0.096cm

3

Problem 11

A steel pipe fixed at one end is subjected to a torque of 100,000 N-m. The pipe is originally 3 m in length with an outside diameter of 35 cm and a wall thickness of 1 cm. Steel has a modulus of elasticity of 210 GPa and a Poisson's ratio of 0.30. What is the resulting angle of twist of the pipe?

    A. 0.0004 rad
    B. 0.0008 rad
    C. 0.012 rad
    D. 0.024 rad

Problem 11

$Force = N$
$Length = m$
$\therefore stress = Pa$

$$\phi = \frac{TL}{GJ}$$

A steel pipe fixed at one end is subjected to a torque of 100,000 N-m. The pipe is originally 3 m in length with an outside diameter of 35 cm and a wall thickness of 1 cm. Steel has a modulus of elasticity of 210 GPa and a Poisson's ratio of 0.30. What is the resulting angle of twist of the pipe?

A. 0.0004 rad

B. 0.0008 rad

C. 0.012 rad

D. 0.024 rad

$T = 100,000 \, N\text{-}m$

$L = 3m$

$G = \dfrac{E}{2(1+v)} = \dfrac{210 \, GPa}{2(1+0.3)} = \dfrac{80.77 \, GPa}{= 80.77 \times 10^9 \, Pa}$

$J = \dfrac{\pi(d_o^4 - d_i^4)}{32} = \dfrac{\pi\left[(0.35m)^4 - (0.33m)^4\right]}{32}$

$= 3.09 \times 10^{-4} \, m^4$

$\therefore \phi = \dfrac{(100000 \, N\text{-}m)(3m)}{(80.77 \times 10^9 \, Pa)(3.09 \times 10^{-4} \, m^4)} = 0.012 \, rad$

Problem 12

A beam has a triangular cross-section as shown. What is the maximum compressive stress in the beam?

w = 80 N/m

10 cm   10 cm

12 cm

10 m

A. 7.8 MPa

B. 15.6 MPa
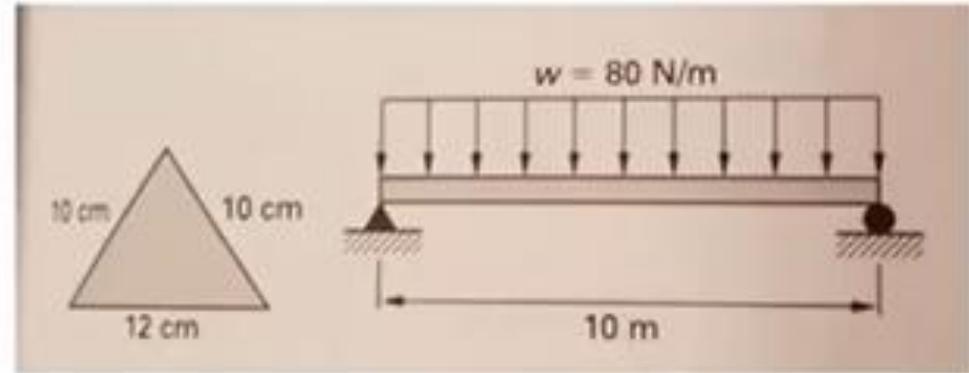
C. 23.4 MPa

D. 31.3 MPa

Problem 12
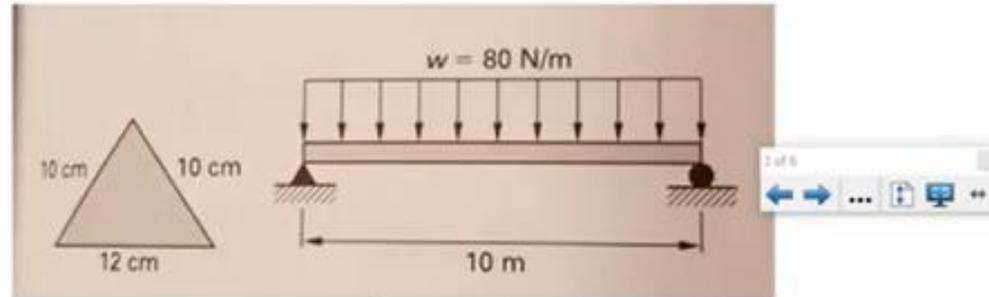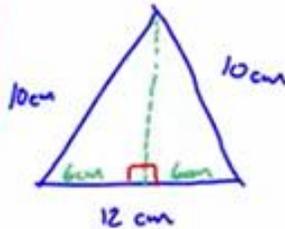
Force = N

Length = m

$\sigma = \frac{My}{I}$

$M_{max} = \frac{wL^2}{8}$, $y = \frac{2h}{3}$, $I = \frac{bh^3}{36}$

A beam has a triangular cross-section as shown. What is the maximum compressive stress in the beam?

w = 80 N/m

10 cm   10 cm

12 cm

10 m

A. 7.8 MPa

B. 15.6 MPa

C. 23.4 MPa

D. 31.3 MPa

$w = 80 \, N/m$
$L = 10 \, m$

$M = \frac{wL^2}{8} = \frac{(80 \, N/m)(10m)^2}{8} = 1000 \, N\text{-}m$

10cm   10cm

10cm

6cm   6cm

12 cm

$h = 8 \, cm = 0.08m$
$b = 12 \, cm = 0.12m$

$\therefore \quad y = \frac{2h}{3} = \frac{2}{3}(0.08m) = 0.0533 \, m$

$I = \frac{bh^3}{36} = \frac{(0.12m)(0.08m)^3}{36} = 1.71 \times 10^{-6} \, m^4$

$\sigma = \frac{(1000 \, N\text{-}m)(0.0533m)}{1.71 \times 10^{-6} \, m^4} = 3.12 \times 10^7 \, Pa$

$= 3.12 \times 10^1 \, MPa$

$= 31.2 \, MPa$

5

Problem 13

A rectangular beam 4 cm wide and 6 cm high is subjected to a shear of 7000 N at a particular location. The beam is constructed of 2014-T3 aluminum. What is most nearly the maximum shear stress at that location?

    A. 290 N/cm²

    B. 440 N/cm²

    C. 520 N/cm²

    D. 660 N/cm²

Problem 13

$$\tau = \frac{VQ}{Ib}$$

A rectangular beam 4 cm wide and 6 cm high is subjected to a shear of 7000 N at a particular location. The beam is constructed of 2014-T3 aluminum. What is most nearly the maximum shear stress at that location?

A. 290 N/cm²

B. 440 N/cm²

C. 520 N/cm²

D. 660 N/cm²

$V = 7000 \, N$

$b = 4 \, cm$

$h = 6 \, cm$
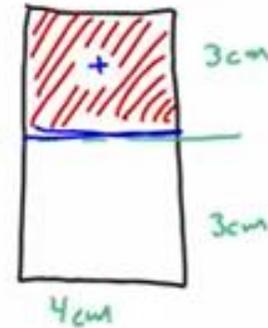
$I = \frac{bh^3}{12} = \frac{(4 \, cm)(6cm)^3}{12} = 72 \, cm^4$

$\therefore \tau = \frac{VQ}{Ib} = \frac{(7000 N)(18 \, cm^3)}{(72 \, cm^4)(4 cm)} = 437.5 \, N/cm^2$

Q1

$A = 12 \, cm^2$

$y = 1.5 \, cm$

$\therefore Q = A_y = 18 \, cm^3$

Problem 14

Given the following, what is most
nearly the maximum shear stress?

$$\sigma_x = -140 \text{ MPa}$$
$$\sigma_y = 205 \text{ MPa}$$
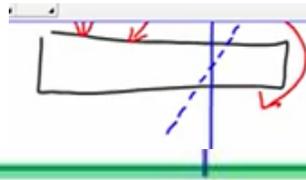$$\tau_{xy} = 100 \text{ MPa}$$

A. 100 MPa
B. 160 MPa
C. 200 MPa
D. 210 MPa

Problem 14

Given the following, what is most nearly the maximum shear stress?

$$\sigma_x = -140 \text{ MPa}$$

$$\sigma_y = 205 \text{ MPa}$$
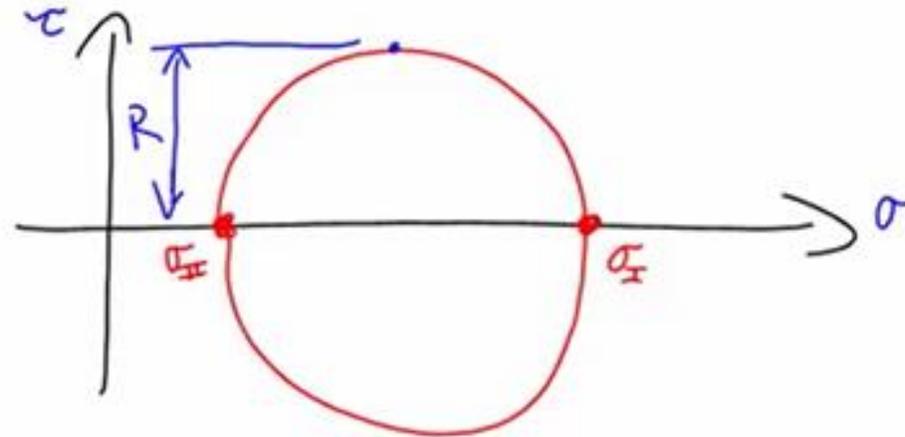
$$\tau_{xy} = 100 \text{ MPa}$$

A. 100 MPa

B. 160 MPa

C. 200 MPa

D. 210 MPa

$$\tau_{max} = R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \sqrt{\left(\frac{-140 - 205}{2}\right)^2 + (100)^2} = 199.4$$

Problem15

A rectangular steel bar 37.5 mm wide and 50 mm thick is pinned at each end and subjected to axial compression. The bar has a length of 1.75 m. The modulus of elasticity is 200 GPa. What is the critical buckling load?

A. 60 kN
B. 93 kN
C. 110 kN
D. 140 kN

Problem 15

$$\text{Force} = kN \left. \right\} \quad kN/mm^2 = GPa \qquad P_{cr} = \frac{\pi^2 EI}{(kL)^2}$$
$$\text{Length} = mm$$

A rectangular steel bar 37.5 mm wide and 50 mm thick is pinned at each end and subjected to axial compression. The bar has a length of 1.75 m. The modulus of elasticity is 200 GPa. What is the critical buckling load?

A. 60 kN

B. 93 kN

C. 110 kN

D. 140 kN

$$L = 1.75m = 1750\,mm$$
$$E = 200\,GPa$$
$$k = 1.0$$

$$I = \frac{bh^3}{12} = \frac{(50\,mm)(37.5\,mm)^3}{12}$$
$$= 2.197 \times 10^5 \, mm^4$$

$$I_x = \frac{37.5(50^3)}{12}$$
$$I_y = \frac{50(37.5^3)}{12}$$

$$\therefore P_{cr} = \frac{\pi^2 EI}{(kL)^2} = \frac{\pi^2 (200\,GPa)(2.197 \times 10^5 \, mm^4)}{(1750\,mm)^2}$$
$$= 141.6 \, kN$$

Problem 15

15. A 0.25-m steel rod with a cross-sectional area of 1,250 mm2 and a modulus of elasticity *E* of 200 GPa is subjected to a 5,000-N force as shown below. The elongation of the rod (μm) is most nearly:

5,000 N ← ⊂========================⊃ → 5,000 N

|← 0.25 m →|
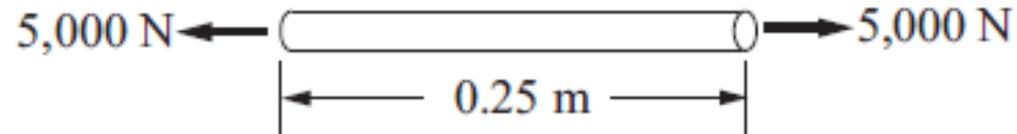
- o A. 2.4
- o B. 4.4
- o C. 5.0
- o D. 9.6

Problem 15

From the Uniaxial Loading and Deformation section in the Mechanics of Materials chapter of the *FE Reference Handbook*, the uniaxial deformation is:

$$\text{Deformation} = \delta = \frac{PL}{AE} = \frac{(5,000)(0.25)}{(1,250 \times 10^{-6})(200 \times 10^{9})} = 5.0 \times 10^{-6} \text{ m} = 5.0 \text{ } \mu\text{m}$$

THE CORRECT ANSWER IS: C

Problem 16

16. In general, a metal with high hardness will also have which of the following characteristics? Select **all** that apply.

☐ A. Good formability

☐ B. Strong intermolecular bonding   **YES, page 139 of FE Handbook**

☐ C. High tensile strength   **YES, page 100 of FE Handbook**

☐ D. High yield strength   **YES, page 139 of FE Handbook**

☐ E. High oxygen permeability

☐ F. High abrasion/scratch resistance   **YES, page 139 of FE Handbook**

Problem 16

Refer to the Relationship Between Hardness and Tensile Strength section in the Mechanics of Materials chapter of the *FE Reference Handbook.*

By definition, a metal with high hardness has a high tensile and yield strength, as well as strong intermolecular bonding, with high impact, rebound, and scratch resistance strength.

THE CORRECT ANSWERS ARE: B, C, D, AND F

Problem 17

17. If an aluminum crimp connector were used to connect a copper wire to a battery, what would most likely happen?

- ○ A. Only the copper wire will corrode.
- ○ B. Only the aluminum connector will corrode.
- ○ C. Both will corrode.
- ○ D. Nothing

Problem 17

Refer to the Corrosion section in the Mechanics of Materials chapter of the *FE Reference Handbook.* Aluminum is anodic relative to copper and therefore will corrode to protect the copper.

THE CORRECT ANSWER IS: B

Problem 18

18. Glass is said to be an amorphous material. This means that it:

- ○ A. has a high melting point
- ○ B. is a supercooled vapor
- ○ C. has large cubic crystals
- ○ D. has no apparent crystal structure

Problem 18

Refer to the Amorphous Materials section in the Mechanics of Materials chapter of the *FE Reference Handbook*. By definition, amorphous materials do not have a crystal structure.

THE CORRECT ANSWER IS: D

Problem 94

The pressure gauge in an air cylinder reads 1,680 kPa. The cylinder is constructed of a 12-mm rolled-steel plate with an internal diameter of 700 mm. The tangential (hoop) stress (MPa) inside the tank is most nearly:

○   A. 25
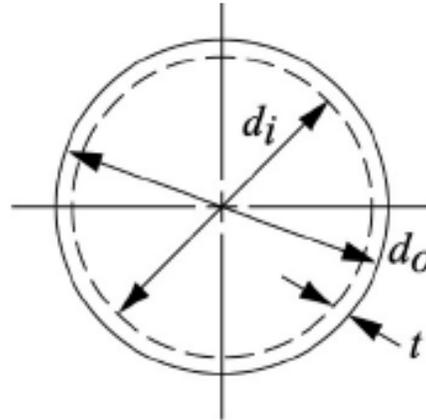
○   B. 50

○   C. 77

○   D. 100

Problem 94

Refer to page 132 in the Cylindrical Pressure Vessel section in the Mechanics of Materials chapter of the *FE Reference Handbook*.

The cylinder can be considered thin-walled if $t < d_o/20$. In this case, $t = 12$ mm and $r_o = d_o/2 = 362$ mm. Thus, the σ_t = tangential (hoop) stress is:

$$\sigma_t = \frac{P_i r}{t}$$

$$\text{where } r = \frac{r_i + r_o}{2} = \frac{350 + 362}{2} = 356 \text{ mm}$$

$$\sigma_t = \frac{(1.680 \text{ MPa})(356 \text{ mm})}{12 \text{ mm}} = 49.8 \text{ MPa}$$

THE CORRECT ANSWER IS: B

Problem 95

What is the total longitudinal strain in a 1m long where Young's modulus (the modulus of elasticity), E, is 210 GPa and Poisson's ratio, v, $= 0.24$

$\sigma_l = 23.1$ MPa
$\sigma_t = 46.2$ MPa
$\sigma_r = 0$

Problem 95

Refer to the Hooke's Law section in the Mechanics of Materials chapter on page 134 of the *FE Reference Handbook*.

The formula for the total longitudinal strain without a temperature rise is:

$$\varepsilon_l = 1/E[\sigma_l - v(\sigma_t - \sigma_r)]$$

where Young's modulus (the modulus of elasticity), E, = 210 GPa   & Poisson's ratio, v, = 0.24

$$\varepsilon_{axial} = \frac{1}{E}\left(\sigma_l - v(\sigma_t + \sigma_r)\right) = \frac{1}{210 \times 10^3 \text{ MPa}}\left(23.1 \text{ MPa} - 0.24(46.2 \text{ MPa} + 0)\right) = 5.72 \times 10^{-6}$$

$$\varepsilon_{axial} = \frac{\delta l}{l}$$, where is the length of the section under consideration

$$\delta l = \varepsilon_{axial} \times l$$

$= 5.72 \times 10^{-6} \times 1{,}000$ mm

$= 0.0572$ mm

THE CORRECT ANSWER IS: A