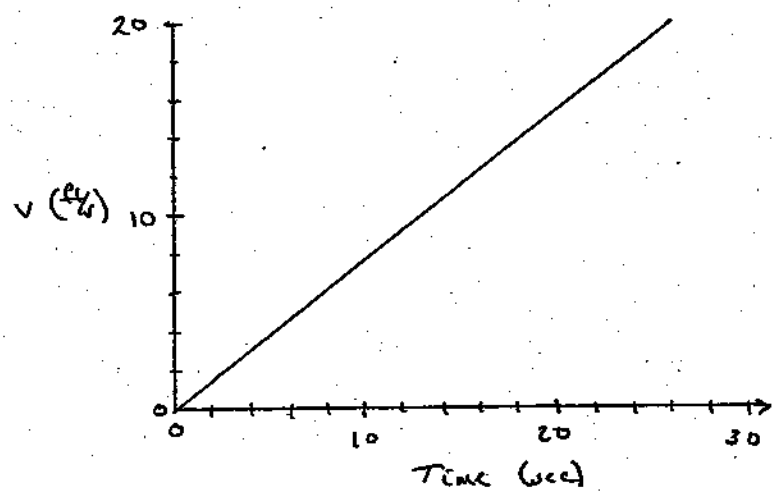
EN 200	Ch 1	Prob 1

a. Sketch the velocity of a YP moving from 0 ft/s to its top speed of 20 ft/s. Time to reach max speed is 26 sec.



Assume velocity is linear

b. Give calculus for area under curve from 0 to 10 sec. What does area physically represent?

$$A = \int_0^{10} v \, dt$$

area represents distance traveled in 10 seconds

c. How to calculate acceleration of YP at t = 5 sec?

$$a = \frac{dv}{dt}$$ ~ slope of velocity curve at t = 5 sec

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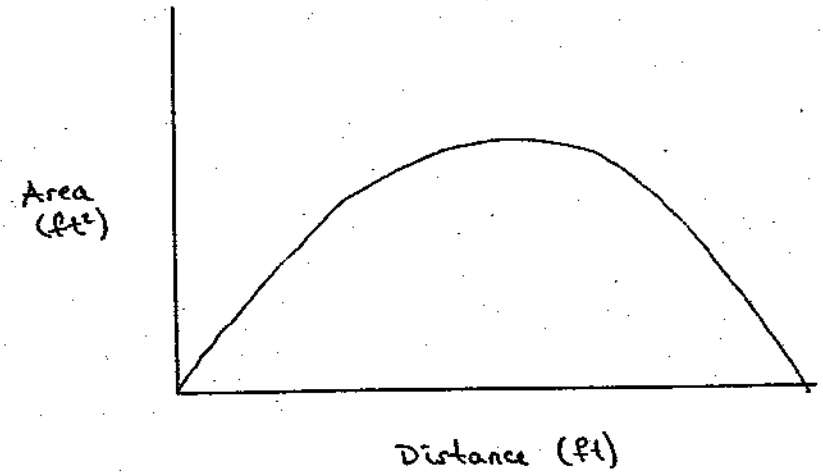
2. What does area under "sectional area" vs "longitudinal distance" curve represent?



Area under curve represents volume (ft^3)

3. Give units for following physical parameters:

Force: lb or LT

Mass: slug or $lb \cdot s^2/ft$

Volume: ft^3

Time: seconds

Density: $slug/ft^3$ or $lb\, s^2/ft^4$

Moment: ft-lb

Couple: ft-lb

Pressure: lb/ft^2 or lb/in^2

2nd moment of area: ft^4

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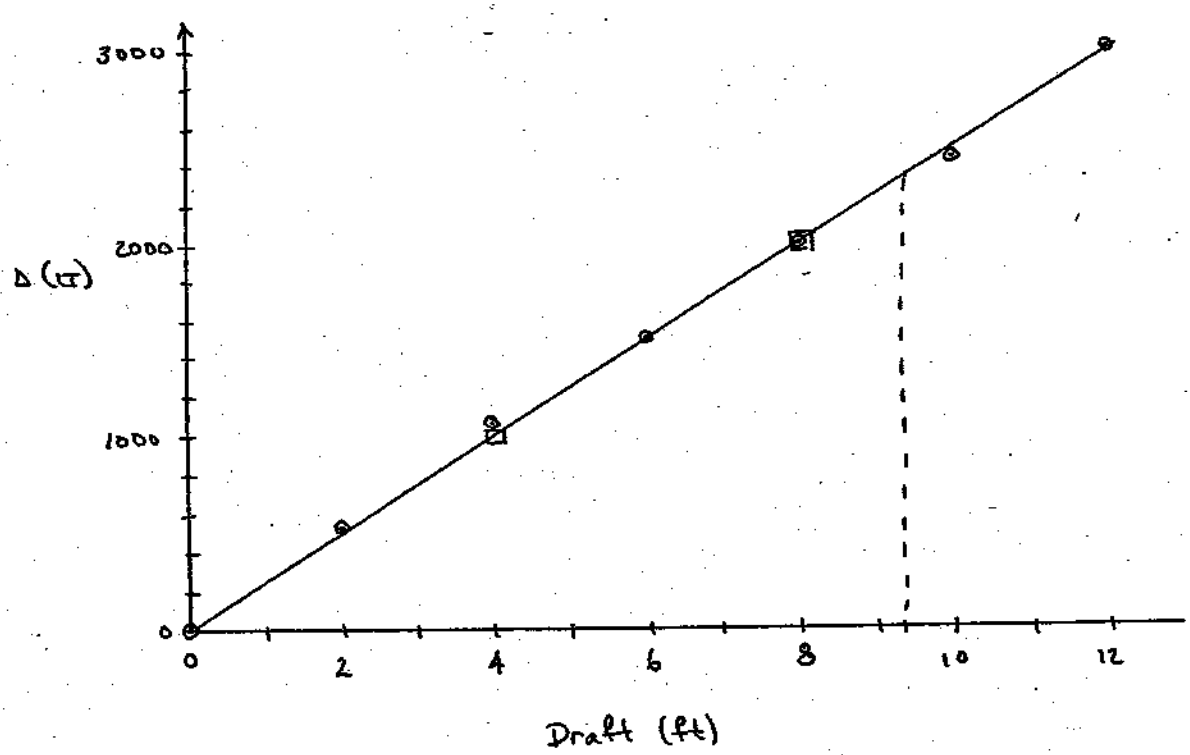
EN 200	Ch 1	Prob 4

Ships displacement varies with draft as shown:

Draft (ft)	Δ (LT)
0	0
2	520
4	1050
6	1480
8	2000
10	2420
12	3000

a) Plot the data



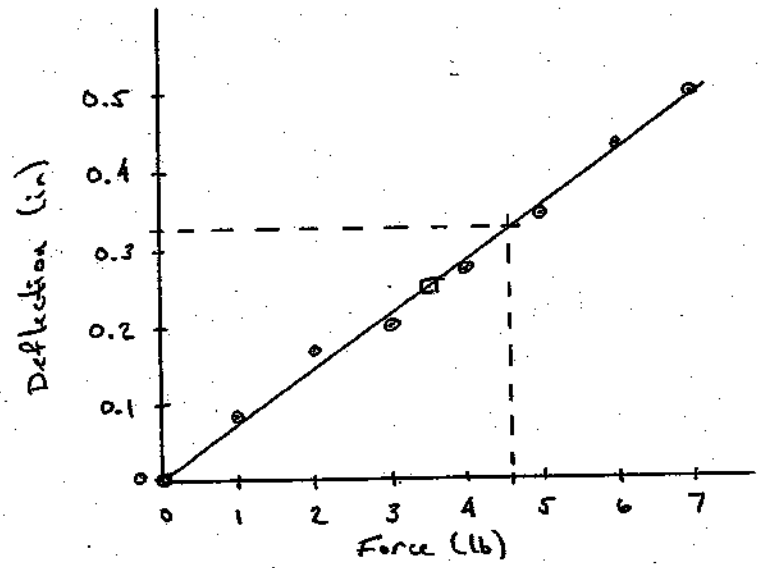
b) calculate slope:

$$\text{slope} = \frac{dy}{dx} = \frac{\Delta_2 - \Delta_1}{T_2 - T_1} = \frac{2000\ LT - 1000\ LT}{8\ ft - 4\ ft} = 250\ LT/ft$$

c) slope represents how ship's weight changes with draft

Deflection of a spring varies with the force applied as shown in following data:

Force (lb)	Deflection (in)
0	0
1	0.08
2	0.17
3	0.20
4	0.27
5	0.34
6	0.43
7	0.50



a) slope = $\frac{\text{rise}}{\text{run}} = \frac{0.25\text{ in} - 0\text{ in}}{3.5\text{ lb} - 0\text{ lb}} = 0.071$ in/lb

b) slope represents amount of spring deflection per pound applied.

(also, inverse of spring constant)

c) deflection if 4.6 pounds applied: from plot, deflection = 0.33 in

d) equation of curve:

Oiler transfers 100,000 gallons of F-76 to a frigate. $\rho_{fuel} = 1.616\ lb\,s^2/ft^4$

a. Calculate LT fuel transferred

$$W = \rho_{fuel}\, g\, V_{fuel}$$

$$= \left(1.616\ \frac{lb\,s^2}{ft^4}\right)\left(32.17\ \frac{ft}{s^2}\right)\left(100{,}000\ gal\right)\left(\frac{ft^3}{7.4805\ gal}\right)\left(\frac{LT}{2240\ lb}\right)$$

$$W = 310.3\ LT$$

b. If oiler's draft changes 1 inch for every 136 LT added or removed, how many feet will oiler's draft change?

$$\delta T = \frac{W}{136\ LT/in} = \frac{310.3\ LT}{136\ LT/in} = 2.28\ in = 0.19\ ft \text{ decrease}$$

c. If frigate's draft changes 1 inch per 33 LT, how many inches will frigate's draft change?

$$\delta T = \frac{W}{33\ LT/in} = \frac{310.3\ LT}{33\ LT/in} = 9.4\ in$$

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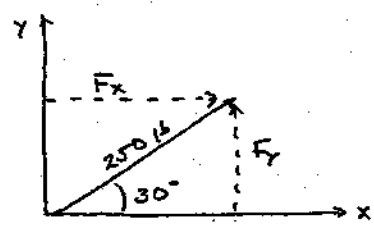
7. Force of 250 lb is acting at an angle of 30° to the x-axis. Determine x & y components of the force.



$F_y = F \sin\theta = (250\text{ lb})(\sin 30°) = 125\text{ lb}$

$F_x = F \cos\theta = (250\text{ lb})(\cos 30°) = 216.5\text{ lb}$

8. What are the conditions for static equilibrium?

$\Sigma F = 0$

$\Sigma M = 0$

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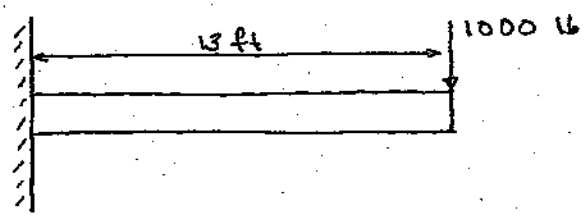
EN 200	Ch 1	Prob 9

1000 lb weight placed at the end of a cantilevered beam as shown. Calculate the magnitude of the moment at the wall.



$M = F \cdot d = (1000\ lb)(13\ ft)$

$M = 13000\ ft\text{-}lb$

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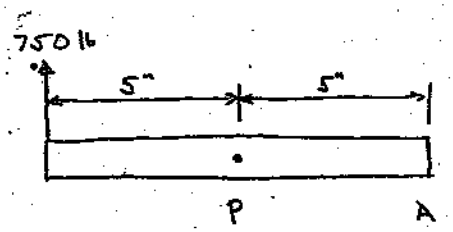
EN 200	Ch1	Prob 10

750 lb force is applied to a linkage arm as shown. Arm pivots about "P".

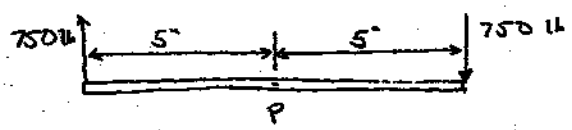


a) A second force is to be applied at "A". What is the necessary magnitude and direction of this force to create a couple about "P"?

Couple is 2 forces of equal magnitude, acting parallel to each other, acting in opposite directions.

F = 750 lb, acting down.

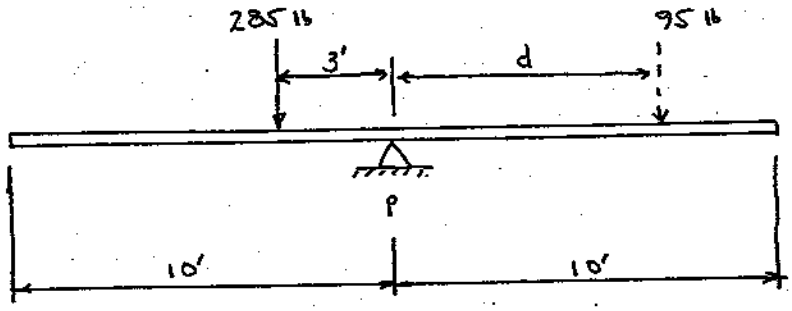
b) What is magnitude of couple?

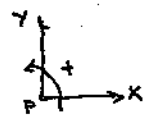


$C = F \cdot d = (750\ lb)(10\ in)$

$C = 7500\ in \cdot lb$

A 285 lb football player is sitting on a see-saw as shown. Where must a 95 lb gymnast sit in order to balance the see-saw? What is the force at "P"?





To balance, gymnast must be right of "P".

use P as origin & sum moments about P:

$$\Sigma M_P = 0$$

$$(285\text{ lb})(3\text{ ft}) - (95\text{ lb})(d) = 0$$

$$d = \frac{(285\text{ lb})(3\text{ ft})}{95\text{ lb}}$$

$$d = 9\text{ ft}$$

Force at "P":

for equilibrium, $\Sigma F = 0$

$$F_P - 285\text{ lb} - 95\text{ lb} = 0$$

$$F_P = 285\text{ lb} + 95\text{ lb}$$

$$F_P = 380\text{ lb}$$

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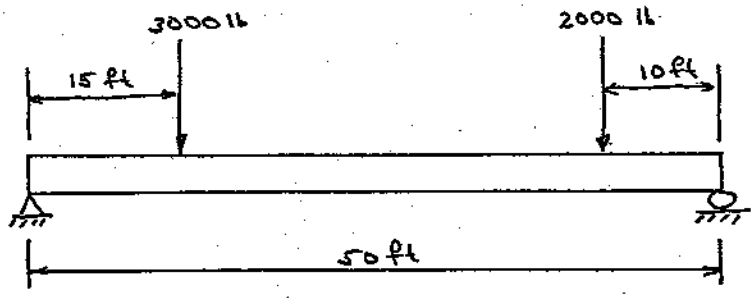
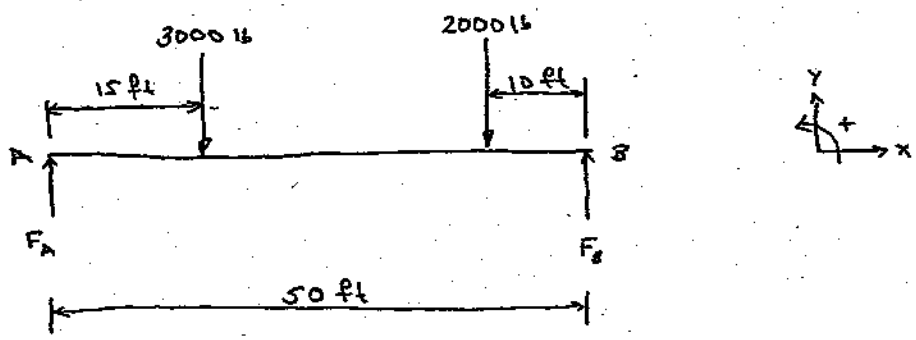
Simply supported beam 50 ft in length. Calculate vertical reaction forces at each end of beam.



free body diagram



$\Sigma F_y = 0$: $F_A + F_B - 2000\text{ lb} - 3000\text{ lb} = 0$

$\Sigma M_A = 0$: $(50\text{ ft})(F_B) - (15\text{ ft})(3000\text{ lb}) - (40\text{ ft})(2000\text{ lb}) =$

$(50\text{ ft})(F_B) = 45000\text{ ft-lb} + 80000\text{ ft-lb} = 125000$

$$F_B = \frac{125000\text{ ft-lb}}{50\text{ ft}}$$

$$\boxed{F_B = 2500\text{ lb}}$$

solve for F_A:

$$F_A = 2000\text{ lb} + 3000\text{ lb} - F_B$$
$$= 5000\text{ lb} - 2500\text{ lb}$$

$$\boxed{F_A = 2500\text{ lb}}$$

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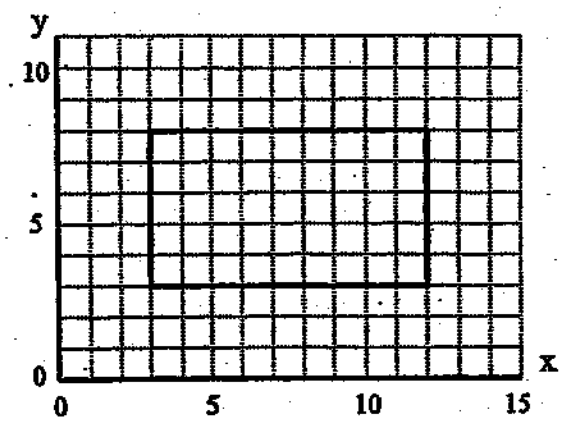
Determine first moment of area about x & y axis



Moment about x-axis:

$M_x = A\bar{y}$

$A = (5)(9) = 45$

$\bar{y} = 5.5 = 3 + \frac{8-3}{2}$

$M_x = (45)(5.5) = 247.5$

Moment about y-axis:

$M_y = A\bar{x}$

$\bar{x} = 3 + \frac{12-3}{2} = 7.5$

$M_y = (45)(7.5) = 337.5$

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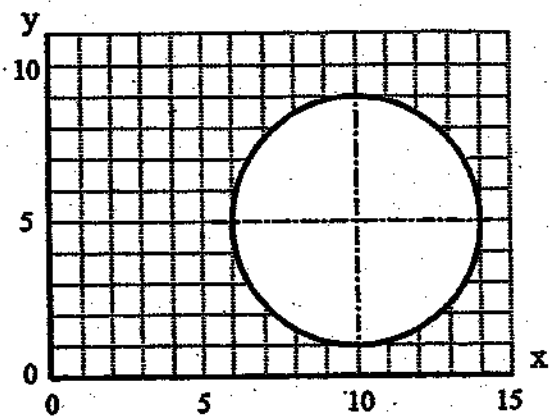
EN 200	Ch1	Prob 15

Determine the first moment of area about the x & y axes



$M_x = A\bar{y}$

$M_y = A\bar{x}$

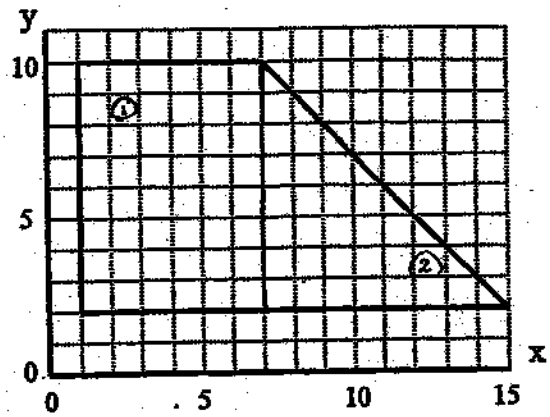
$A = \pi r^2 = \pi \frac{d^2}{4} = \pi \frac{8^2}{4} = 50.26$

$\bar{y} = 5 \qquad \bar{x} = 10$

$M_x = (50.26)(5) = 251.3$

$M_y = (50.26)(10) = 502.6$

Determine centroid of shape about x & y axes



Centroid: $\bar{x} = \frac{M_y}{A} = \frac{\Sigma A_i \bar{x}_i}{\Sigma A_i}$

$\bar{y} = \frac{M_x}{A} = \frac{\Sigma A_i \bar{y}_i}{\Sigma A_i}$

Divide shape into 2 small geometric shapes

$$\bar{x} = \frac{A_1\bar{x}_1 + A_2\bar{x}_2}{A_1 + A_2}$$

$A_1 = (6)(8) = 48$

$A_2 = \frac{1}{2} bh = \frac{1}{2}(8)(8) = 32$

$\bar{x}_1 = 1 + \frac{7-1}{2} = 4$

$\bar{x}_2 = 7 + \frac{1}{3} b = 7 + \frac{1}{3}(8) = 9.67$

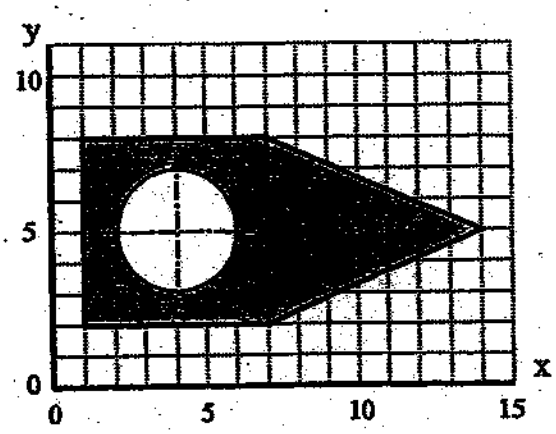
$$\bar{x} = \frac{(48)(4) + (32)(9.67)}{\underbrace{48 + 32}_{80}} = \boxed{6.27}$$

$$\bar{y} = \frac{A_1\bar{y}_1 + A_2\bar{y}_2}{A_1 + A_2}$$

$\bar{y}_1 = 2 + \frac{10-2}{2} = 6$

$\bar{y}_2 = 2 + \frac{1}{3} h = 2 + \frac{1}{3}(8) = 4.67$

Determine centroid of shaded area about x & y axis



$$\bar{x} = \frac{\Sigma M_y}{\Sigma A} \qquad \bar{y} = \frac{\Sigma M_x}{\Sigma A}$$

Divide shape into 3 geometric shapes:
① Square
② Triangle
③ Circle

$$\bar{x} = \frac{A_1 \bar{x}_1 + A_2 \bar{x}_2 - A_3 \bar{x}_3}{A_1 + A_2 - A_3}$$

$$A_1 = 36$$

$$A_2 = \frac{1}{2} bh = \frac{1}{2}(\overset{6}{8-2})(\overset{7}{14-7}) = 21$$

$$A_3 = \pi r^2 = \pi (2)^2 = 12.57$$

$$\bar{x}_1 = 1 + \left(\frac{7-1}{2}\right) = 4 \qquad \bar{y}_1 = 5$$

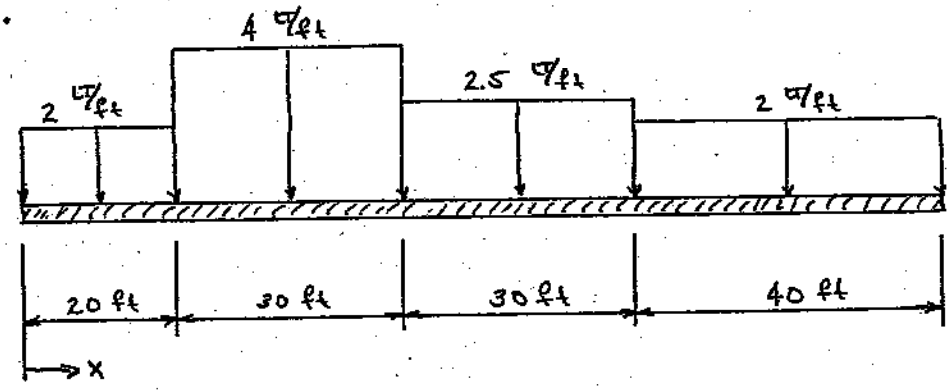
$$\bar{x}_2 = 7 + \frac{1}{3}(14-7) = 9.33 \qquad \bar{y}_2 = 5$$

$$\bar{x}_3 = 4 \qquad \bar{y}_3 = 5$$

$$\bar{x} = \frac{(36)(4) + (21)(9.33) - (12.57)(4)}{\underbrace{36 + 21 - 12.57}_{44.43}} = \boxed{6.52}$$

$$\bar{y} = \frac{A_1 \bar{y}_1 + A_2 \bar{y}_2 - A_3 \bar{y}_3}{A_1 + A_2 - A_3} = \frac{(36)(5) + (21)(5) - (12.57)(5)}{}$$

Diagram shows distributed weight of a small ship.



a) Distributed force acts over the entire length, area, or volume of a body.

Resultant force is a summation of the distributed force, and acts at a point (centroid) of the body.

b) resultant weight of the ship:

$$\Delta = (20\,ft)(2\,LT/ft) + (30\,ft)(4\,LT/ft) + (30\,ft)(2.5\,LT/ft) + (40\,ft)(2\,LT/ft)$$

$$\Delta = 315\ LT$$

c) at what point would resultant weight be applied?

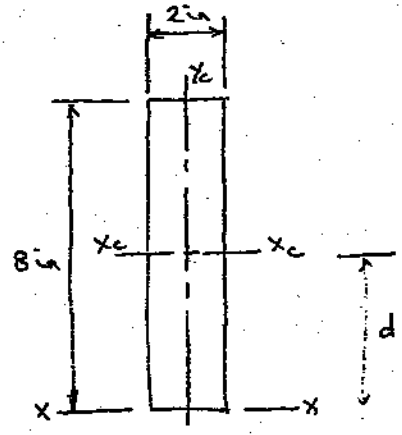
location of Δ will be at x_R.

$$x_R = \sum x_i \frac{F_i}{\Delta} = \frac{x_1 F_1}{\Delta} + \frac{x_2 F_2}{\Delta} + \frac{x_3 F_3}{\Delta} + \frac{x_4 F_4}{\Delta}$$

$$= (10\,ft)\left(\frac{40\,LT}{315\,LT}\right) + (35\,ft)\left(\frac{120\,LT}{315\,LT}\right) + (65\,ft)\left(\frac{75\,LT}{315\,LT}\right) + (100\,ft)\left(\frac{80\,LT}{315\,LT}\right)$$

$$x_R = 55.5\ ft$$

Calculate 2nd moment of area about given axes.



a) 2nd moment about x_c

$$i_{x_c} = \frac{bh^3}{12} = \frac{(2\,in)(8\,in)^3}{12} = \boxed{85.33\ in^4}$$

b) 2nd moment about y_c:

$$i_{y_c} = \frac{hb^3}{12} = \frac{(8\,in)(2\,in)^3}{12} = \boxed{5.33\ in^4}$$

c) 2nd moment about x-x

$$i_{xx} = i_{x_c} + A d^2$$

$$= 85.33\ in^4 + (2in)(8in)(4in)^2$$

$$\boxed{i_{xx} = 341.33\ in^4}$$

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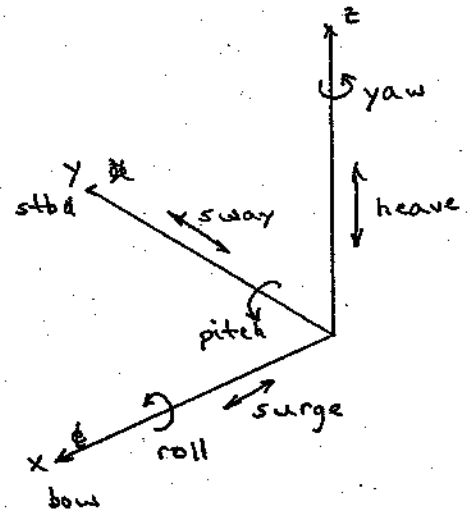
20) Sketch diagram show six degree of freedom for a ship.



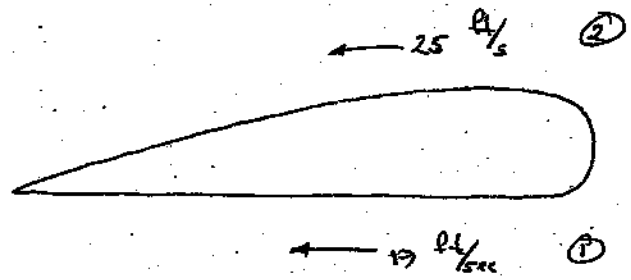
21) Describe difference between list, heel, roll

List: static angle of rotation about x axis produced by weight shift on ship.

Heel: static angle produced by external force such as wind

Roll: dynamic rotation about x axis

8. Given the hydrofoil section and flow velocities:



Bernoulli's equation:

$$\frac{P_1}{\rho} + \frac{V_1^2}{2} + g z_1 = \frac{P_2}{\rho} + \frac{V_2^2}{2} + g z_2$$

* For a hydrofoil section, z_1 approximately equal to z_2

so, $$\frac{P_1}{\rho} + \frac{V_1^2}{2} = \frac{P_2}{\rho} + \frac{V_2^2}{2}$$

or $$= \frac{P_1}{\rho} - \frac{P_2}{\rho} = \frac{V_2^2}{2} - \frac{V_1^2}{2}$$

$$\frac{1}{\rho}(P_1 - P_2) = \frac{1}{2}(V_2^2 - V_1^2)$$

$$(P_1 - P_2) = \frac{\rho}{2}(V_2^2 - V_1^2)$$

$$= \frac{\rho}{2}\left[\left(25\,\frac{ft}{s}\right)^2 - \left(19\,\frac{ft}{s}\right)^2\right]$$

$$\therefore\ P_1 - P_2 = \frac{\rho}{2}\left(264\,\frac{ft^2}{s^2}\right)$$

Physical significance: Pressure at ① is greater than at ②, therefore the foil is generating lift