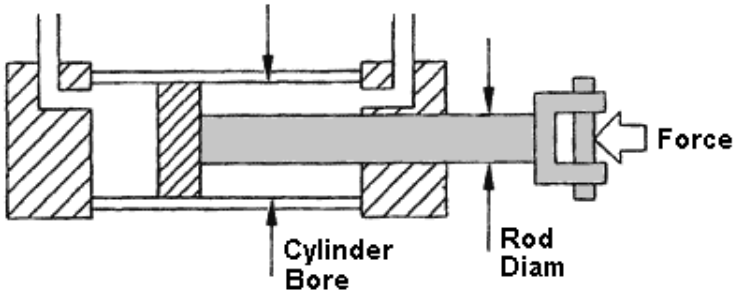
Fluid Statics



Q6: A pneumatic cylinder is operating at 856kPa. The cylinder diameter is 89mm and the rod diameter is 22mm.
(a) What is the extension (pushing) force?

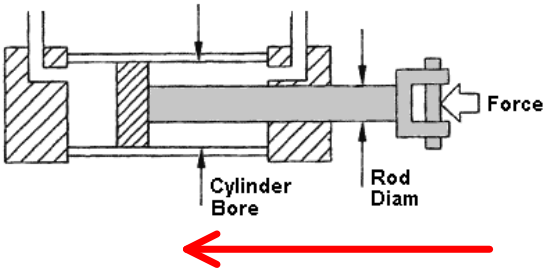
Pressure = Force / Area
(MPa) (N) (mm^2)
or...
(Pa) (N) (m^2)

Area = Pi*89^2/4 = 6221.14 mm^2
F = pA
= 0.856 * 6221.14 = 5325.3 N
} Works ...

or...
Area = Pi*0.089^2/4 = 0.00622114 m^2
= 856E3 *0.00622114 = 5325.3 N
} Better...

Engineers like to use mm when working with stress so they automatically get answer in MPa. Very common in stresses.
But when working with fluids, it is safer to stick to **m** and **Pa**.

Gauge Pressure: Pressure compared to atmosphere.
Absolute Pressure: Pressure compared to vacuum.



Force when contracting (pulling)
Area = Pi*89^2/4 = 6221.14 mm^2

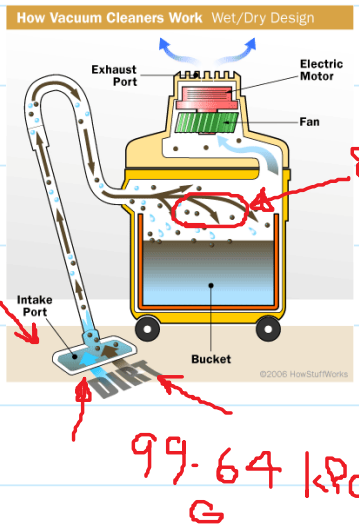
Area = Pi*22^2/4 = 380.133 mm^2

Net Area = 6221.14 - 380.133 = 5841.007 mm^2

F = pA

= 0.856 * 5841.007 = 4999.9 N

Fluid Statics 2



Q9: Johnny tries to suck the last bit of water out of a swimming pool with a vacuum that has an absolute pressure of 82kPa. How high can it raise the water? (The barometric pressure that day was 996.4 millibars)

Standard Temp & Pressure (STP)

T=25°C, P = 101.3 kPa

1 Bar = 100kPa = 100 000 Pa

1mBar = 100 Pa

1 atm = 101.3 kPa

P Atm = 996.4 millibars = 99640 Pa

Pressure difference = 99640 - 82000 = 17640 Pa (17.64 kPa)

$p = \rho g h$

(Pa) (kg/m3)(m/s2)(m)

h = P/ρg = 17640 / (1000*9.81) = 1.7982 m

Absolute pressure = 0 (hard vacuum)

101300 / (1000*9.81) = 10.3262 m

Fluid Statics 3

Q12: In 1960, the Triest reached the bottom of the Marianas Trench (10.911 km). How much load (in kg) was pushing on the viewing window if it was 430mm diameter? (Assume standard atm pressure inside, seawater RD=1.03)

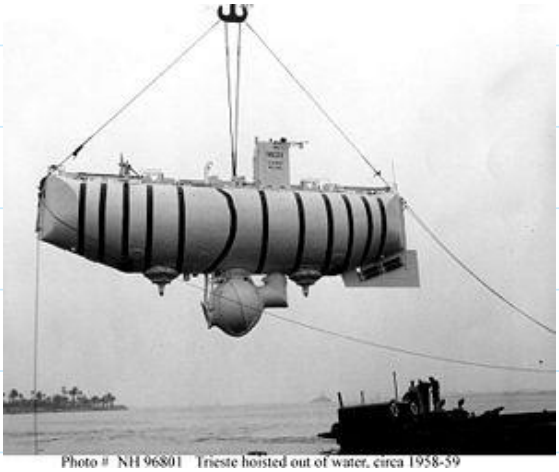


Photo # NH 96801 Trieste hoisted out of water, circa 1958-59

$p = \rho g h$

(Pa) (kg/m3)(m/s2)(m)

= 1030*9.81*10911

= 1.1025E8 Pa

= 1.1025E5 kPa

= 1.1025 E2 MPa

= 110 MPa

Exponent

E8 = $x10^8$

$p = F/A$

A = Pi*0.43^2/4 = 0.14522 m2

F = pA = 1.1025E8* 0.14522

= 1.60105E7 N

= 1.60105E4 kN

= 1.60105E4/9.81

= 1,632.05912 tonnes

Atmospheric…

A = Pi*0.43^2/4 = 0.14522 m2

F = pA = 101325* 0.14522

= 14714.4165 N

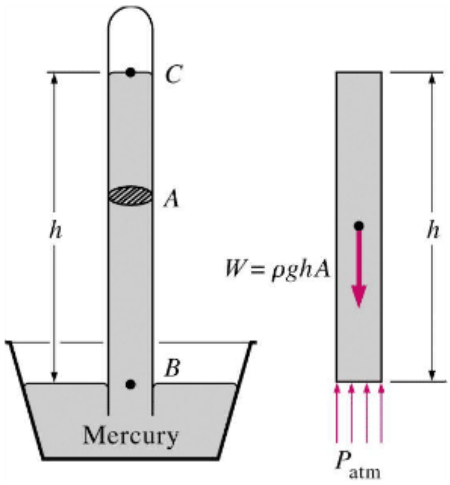
= 14.7 kN

= 14.7/9.81 = 1.4985 tonnes

Fluid Statics 4

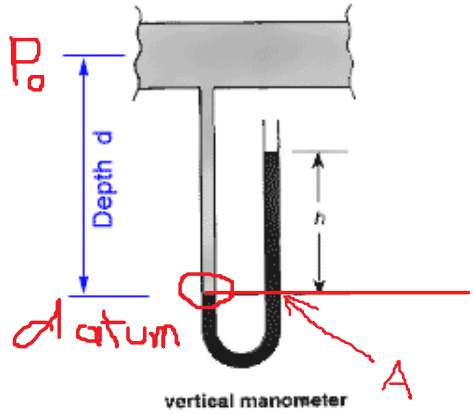
Tuesday, 9 August 2011
7:00 PM

Q13: If atmospheric pressure is 101kPa, what will be the height shown in a mercury barometer? (RD of Hg = 13.534)



$p = \rho gh$
$101000 = 13534*9.81*h$
$h = 101000 / (13534*9.81) =$
$= 0.7607$ m

Q15: A U-tube manometer measures h=236mm. The manometer fluid (ethyl iodide RD=1.936) interface is 414mm from centreline of the pipe carrying pure water, RD=1. Find the gauge pressure at the pipe centreline.



See p221 Example 10.4.
Find pressure at datum in RHS column...

$p = \rho gh$ A
$= 1936 * 9.81 * 0.236$
$= 4482.15$ Pa

This is same as pressure on LHS...

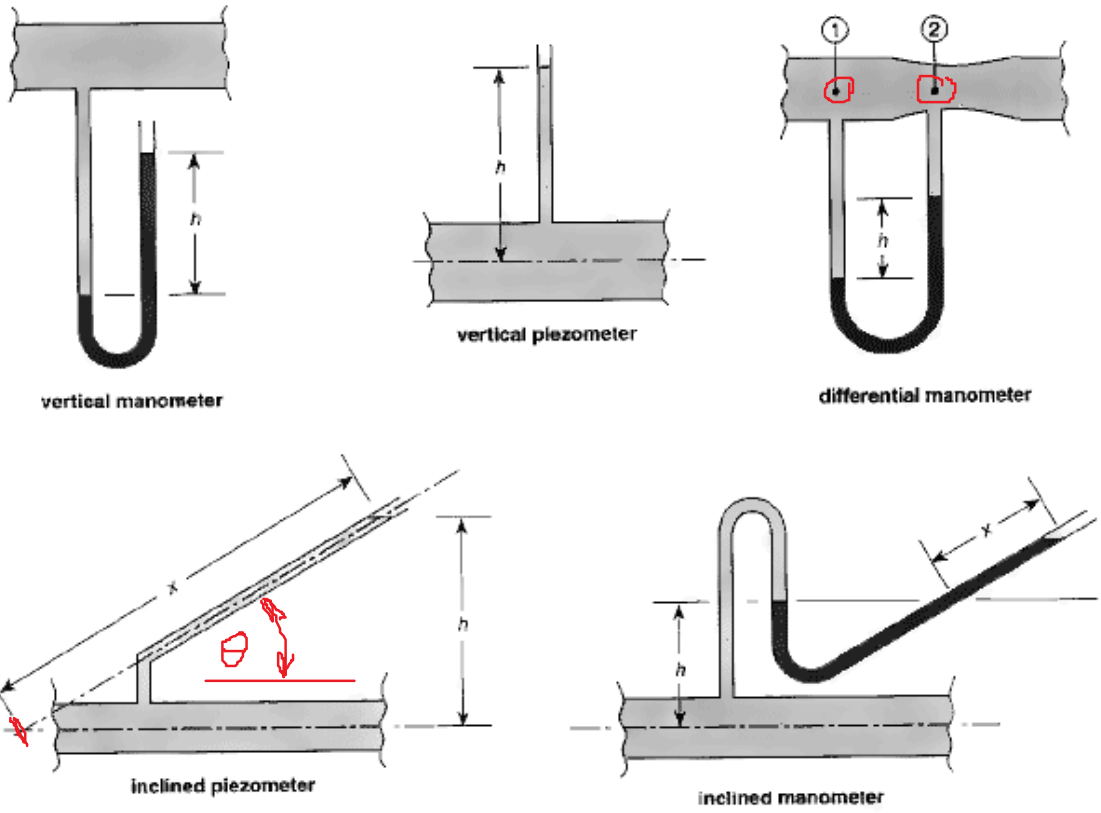
$p = \rho gh + p_o$

$po = p - \rho gh$
$= 4482.15 - 1000 * 9.81 * 0.414$
$= 420.81$ Pa ✓

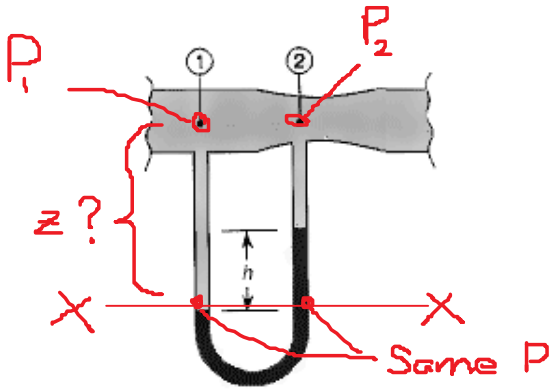
Q20: The door of a vacuum chamber is a 545mm square. What is the equivalent load (kg) applied to the door if a mercury manometer reads a difference of 717 mmHg?

VACUUM CHAMBER:
Area = 0.545^2 = 0.297 m^2
Pressure = 717 mmHg
= 95592.14 Pascals (from CONVERT)
F = pA

= 95592.14 *0.297
= 28390.8 N
= 28.3908 kN
= 28.3908/9.81 = 2.894 tonnes !



Differential Manometer
(Ex: p223)
h = 226mm
manometer fluid = mercury
pipe fluid = water



Datum at X-X:

$p_1 + \rho_w g z = p_2 + \rho_w g(z-h) + \rho_{hg} g h$

$p_1 + \rho_w g z = p_2 + \rho_w g z - \rho_w g h + \rho_{hg} g h$

$p_1 = p_2 - \rho_w g h + \rho_{hg} g h$

$p_1 - p_2 = \rho_{hg} g h - \rho_w g h$

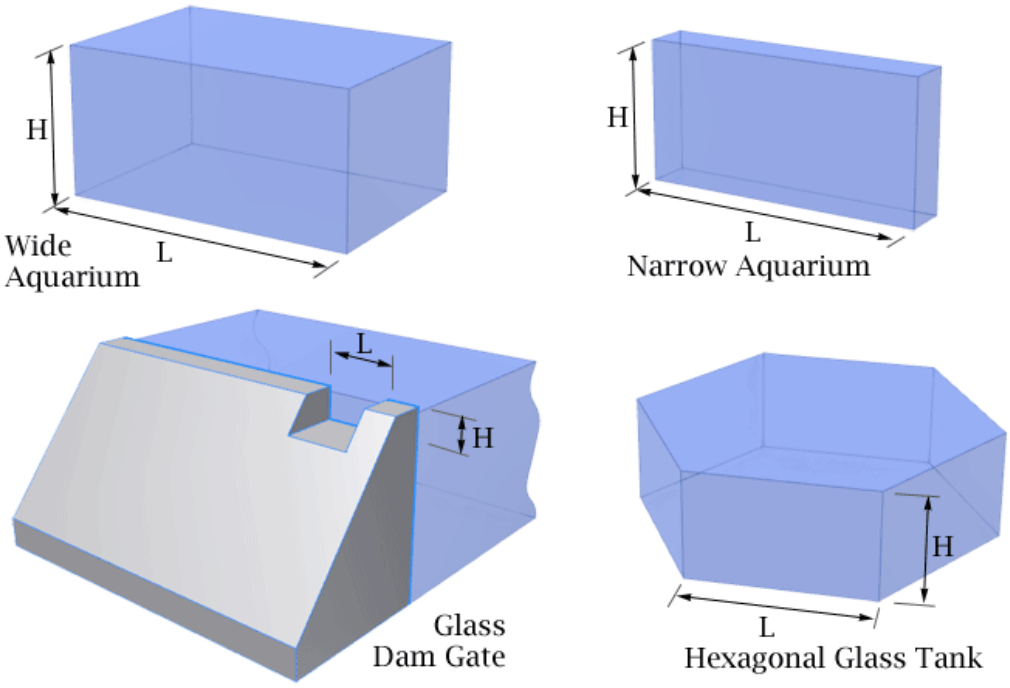
$= 13600*9.81*0.226 - 1000*9.81*0.226$

$= 27934.956$ Pa (27.93 kPa)

Pressure Experiments

Tuesday, 24 July 2012
8:34 PM

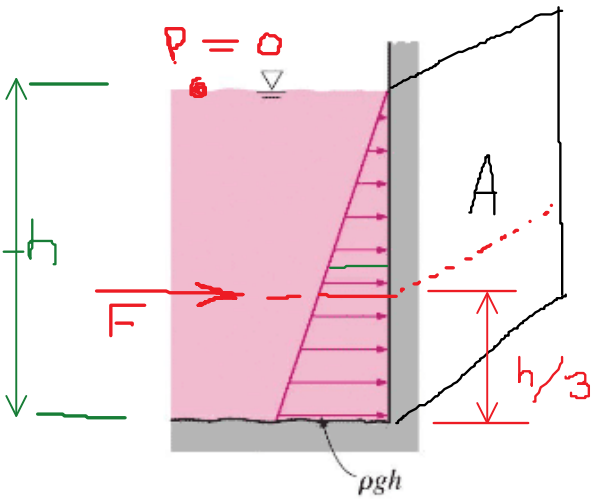
Each glass panel is the same size. Which one has the highest force?

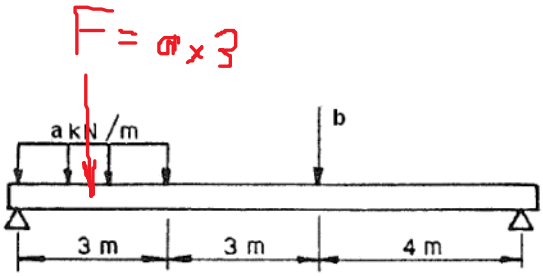


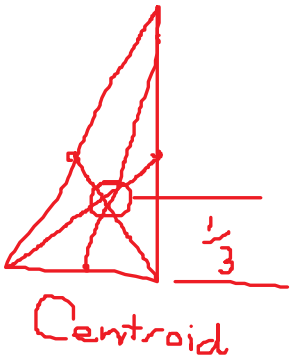
Since pressure only depends on depth, the force is the same in every case.

Forces on Surfaces 1

Tuesday, 9 August 2011
8:26 PM



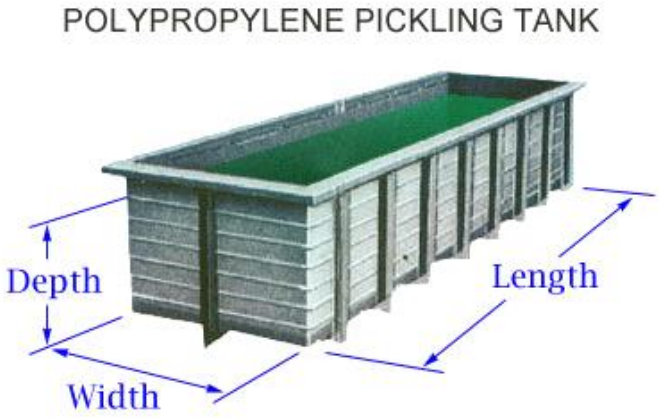




p = F/A. p = ρgh

VERTICAL WALL:

1. Calculate average pressure (at half depth = h/2)
2. Convert into force by F = pA
3. Apply that force at centre of pressure (depth = 2h/3)



Q21: A rectangular pickling tank has a base of 3.5m x 2.6m and holds nitric acid (RD=1.32) to a depth of 2.2m. (a) What is the total force on the base?

F=pA

p = ρgh = 1320 * 9.81* 2.2 = 28488.24 Pa

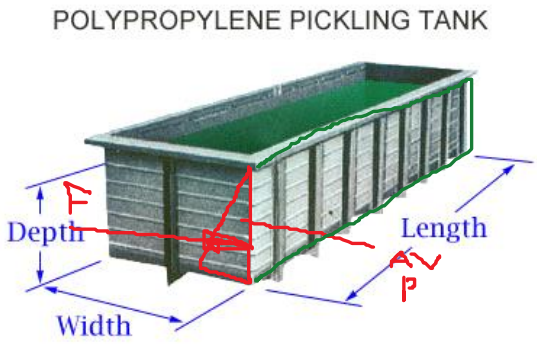
F = pA = 28488.24 * (3.5 * 2.6) = 259242.984 N

This is total force on base..

Check…(Find Weight):

*Volume = 3.5*2.6*2.2 = 20.02 m3*
Density = mass/volume
*Mass = density * volume = 1320*20.02 = 26426.4 kg*
*Weight = mass*gravity = 26426.4*9.81 = 259242.984 N*

Q22: (cont) A rectangular pickling tank has a base of 3.5m x 2.6m and holds nitric acid (RD=1.32) to a depth of 2.2m. (b) What is the total force on the largest side?



Calculate average pressure (at half depth = h/2)

$p = \rho g h = 1320*9.81*(2.2/2) = 14244.12$ Pa

Convert into force by F=PA

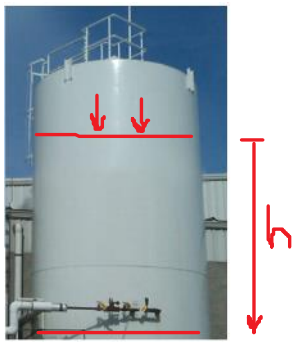
$F = pA = 14244.12 * (3.5 * 2.2) = 109679.724$ N

110 kN is about 110*1000/9.81 = 11213 kg (11.2 tonnes)

Q23: (cont) A rectangular pickling tank has a base of 3.5m x 2.6m and holds nitric acid (RD=1.32) to a depth of 2.2m. (c) At what height is the side force applied? (measured from the bottom surface)

height = 2.2/3 = 0.7333 m

Q25: (cont) A cylindrical tank has a base of diameter 4.4m and vertical height of 4.2m. It is 76% full of oil (RD=0.9) and vapour pressure is 14kPa. (b) Calculate force on bottom.



$p = \rho g h + p_1$
$= 900 * 9.81* (0.76*4.2) + 14000$
$= 42182.168$ Pa
$F = pA = 42182.168 * Pi * 2.2^2$
$= 641393$ N

Forces on Surfaces 2

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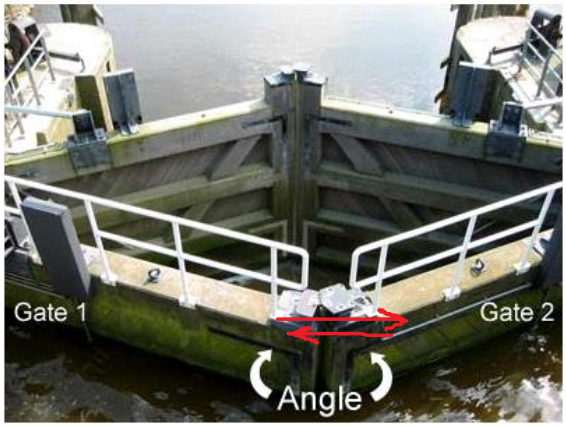
8:55 PM



Q26: Each lock is 5m wide and holds sea-water (RD=1.03) to a depth of 3.8m. (a) What is the force (due to water pressure) against a single lock gate?

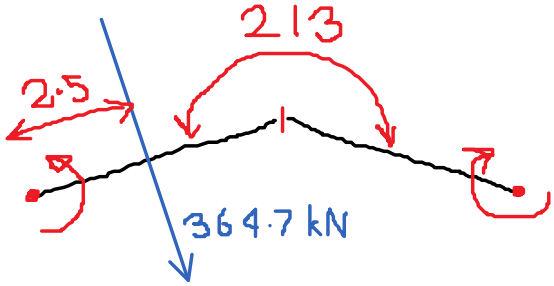
Calculate average pressure (at half depth = h/2)

$p = \rho gh = 1030*9.81*(3.8/2)$
$= 19198.17$ Pa

Convert into force by F=PA

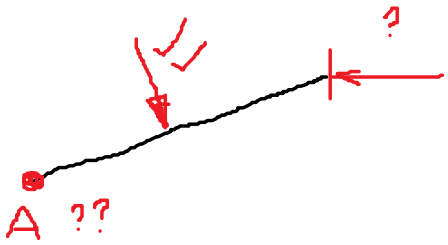
$F=pA = 19198.17 * 5 * 3.8 = 364765.23$ N

Q27: (cont)Each lock is 5m wide and holds sea-water (RD=1.03) to a depth of 3.8m. The closed lock forms an angle of 213 degs on the water side. (b) What moment is required to open one of the lock gates?



$M=Fr = 364765.23 * (5/2)$
$= 911913.075$ Nm

Q28: (cont)Each lock is 5m wide and holds sea-water (RD=1.03) to a depth of 3.8m. The closed lock forms an angle of 213 degs on the water side. (c) What is the compressive force between the lock gates?



Take moment at A
you can do this

Pressure on a submerged surface

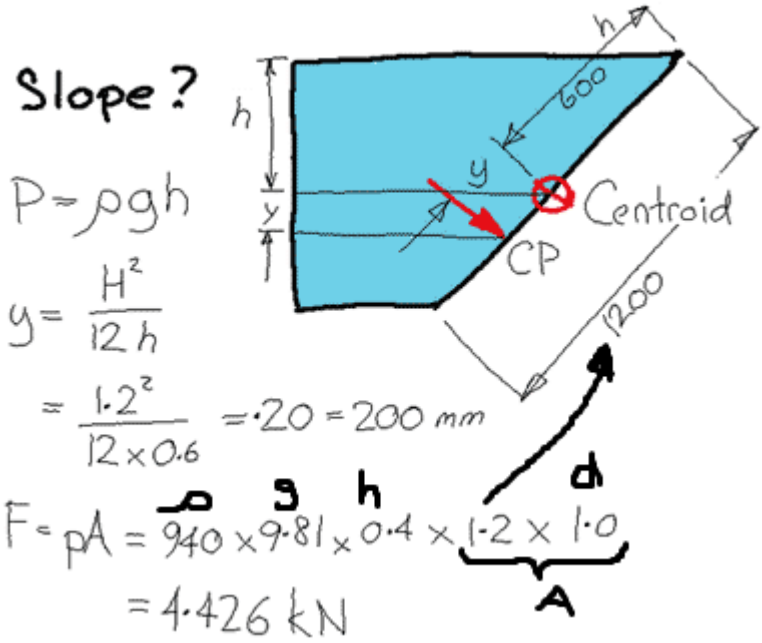
Tuesday, 23 July 2013
8:21 PM

(See Book p225):

Rectangular:

$y = H^2 / 12h$

y = distance from centroid of area to centre of pressure
H = Height of rectangle
h = depth of centroid of area



Circular:

$y = d^2 / 16h$

y = distance from centroid of area to centre of pressure
d = diameter of circular planar surface
h = depth of centroid of area

Buoyancy

Tuesday, 9 August 2011
9:09 PM

Q31: A spherical balloon of diameter 6.8m and weighing 44kg is filled with Helium (Specific Volume = 6.0132 m^3/kg). What is the payload of the balloon? (Assume atmospheric density = 1.225 kg/m^3)

Buoyancy = Mass of air - Mass of balloon

Mass of Air:

$m = \rho * V = 1.225 * 4/3 * Pi * 3.4^3$

$= 201.68$ kg

Mass of Helium:

$\rho = 1 / 6.0132 = 0.1663$ kg/m^3

$m = \rho * V = 0.1663 * 4/3 * Pi * 3.4^3$

$= 27.379$ kg

Buoyancy = Mass of air - Mass of balloon

$= 201.68 - 27.379$

$= 174.301$ kg

Payload = 174.301 - 44 = 130.301 kg