

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 6, Issue 10, October 2017

## Development of Java Programme for Fluid Flow

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**ABSTRACT:** Many fluid problems do not involve motion. They concern the pressure distribution in a static fluid and its effect on solid surfaces and on floating and submerged bodies. When the fluid velocity is zero, denoted as the hydrostatic condition, the pressure variation is due only to the weight of the fluid. Assuming a known fluid in a given gravity field, the pressure may easily be calculated by integration. Important applications in this program are Pressure distribution in the atmosphere and the oceans, Forces on submerged flat surfaces.

**KEYWORDS:** Total Pressure, Centre of Pressure, Fluid Dynamics, Fluid Statics, Fluid Kinematics, Java.

### Nomenclature:

Description	Symbol
Total Pressure Force	A
Distance of C.G. of the area from free surface of liquid	$\bar{h}$
Centre of gravity of plane surface	G
Total pressure force	F
Centre of pressure	P
Distance of centre of pressure from Free surface of liquid.	$h^*$

### I. INTRODUCTION

Fluid mechanics is the branch of science which deals with behaviour of fluids (liquids or gaseous) at rest as well as in motion. Thus this branch of science deals with the statics, kinematics and dynamics aspects of fluid. The study of the fluid at rest is called fluid statics. The study of the fluid in motion, where pressure forces are not considered, is called fluid kinematics and if pressure forces are also considered for the fluid motion, that branch of science is called fluid dynamics. In this programme hydrostatic problems are solved. This programme deals with fluid at rest. This means that there will be no relative motion between adjacent or neighbouring fluid layers. The velocity gradient which is equal to the change of the velocity between two adjacent fluid layers divided by distance between the

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layers will be zero. The shear stress which is equal to  $\mu, du/dy$  will also be equal to zero. Then the forces acting on fluid particles will be: Due to pressure of the fluid normal to the surface, and Due to gravity or self-weight of fluid particles.

## 1) Total Pressure

Total pressure is defined as the force exerted by static fluid on the surface either plane or curved when the fluid comes in contact with the surfaces. This forces always acts normal to the surface. The total pressure force on the surface may be determined by dividing the entire surface into a number of small parallel strips. The force on the small strips is then calculated and total pressure force on the whole area is calculated by integrating force on small strip. For water the value of  $\rho=1000 \text{ kg/m}^3$  and  $g=9.81 \text{ m/s}^2$ . Total Force is given by equation,

$$F = \rho A g \bar{h}$$

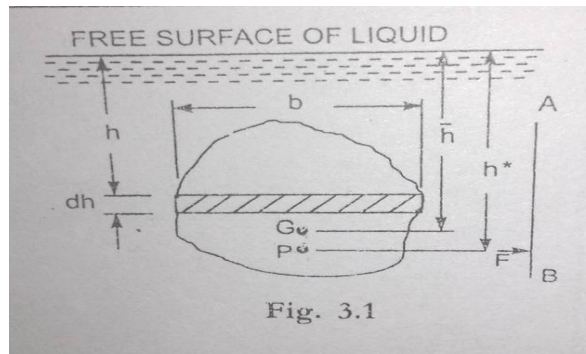


Fig.1 Representation of body submerged in liquid  
Source: Fluid Mechanics and Hydraulic Machine by Dr.R.K.Bansal.

## 2) Centre Of Pressure

It is defined as the point of application of total pressure force on the surface. There are four cases of submerged surfaces on which the total pressure force centre of pressure is to be determined. The submerged surface may be:

- i. Vertical plane surface
- ii. Horizontal plane surface
- iii. Inclined plane surface
- iv. Curved plane surface

Centre of pressure is calculated by using “Principles of moments”, which states that the moment of the resultant force about an axis is equal to sum of the moments of the components about the same axis. Centre of Pressure is given by equation,

$$h^* = I_G / A \bar{h} + \bar{h}$$

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## II. LITERATURE REVIEW

Muhammad Azim Mohd Shariffudiin et al. and Mohamed Nassir [1] has studied the hydrostatic force on curved plate submerged in liquid by experimental setup. In this paper they discussed about the total force acting and centre of pressure acting on curved plate which is submerged in liquid.

Henryk kudela et.al [2] has studied the hydrostatic force acting on horizontal plate submerged in liquid. Henryk submerged the horizontal plate in liquid and calculated the centre of pressure and total force on that submerged body.

Atiqullah and Norman Russel et.al [3] has designed and manufactures the "Hydrostatic and Buoyancy Apparatus" for the laboratory experiment purpose at Southern Polytechnic State University Marietta. By using this apparatus they performed experiment on hydrostatic pressure on curved body submerged in liquid.

## III. RELATED WORK

### 1) JAVA DEVELOPMENT PROGRAMME

```
import java.util.*;
public class f{
public static void main(String args[])
{
Scanner n=new Scanner(System.in);
System.out.println("Fluid Mechanics");
int s;
double a,a1,a2,b,d,F,A,h,h1,h2,h3,I,s1,i1,i2,i3,i4,g1,g2,g3;
System.out.println("This programe will tell us pressure force & centre of pressure");
System.out.println("Enter 1 if your object is Rectangle");
System.out.println("Enter 2 if your object is Traingle");
System.out.println("Enter 3 if your object is circle");
System.out.println("Enter 4 if your object is Trapezium");
s=n.nextInt();
switch(s)
{
case 1:
System.out.println("You have selected rectangular object");
System.out.println("Enter width");
b=n.nextDouble();
System.out.println("Enter depth");
```

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```
d=n.nextDouble();
System.out.println("Enter its distance from free water surface");
s1=n.nextDouble();
A=b*d;
h=s1+(d/2);
F=9810*A*h;
System.out.println("Its distance of C.G. from free surface="+h+"m");
System.out.println("Pressure force=" +F + "Newton");
I=(b*d*d*d)/(12);
h=(s1+d/2);
h1=h+(I)/(A*h);
System.out.println("Moment of Inertia=" +I+"m^4");
System.out.println("Centre of pressure=" +h1 + "metre");
break;
case 2:
System.out.println("You have selected triangular object");
System.out.println("Enter base");
b=n.nextDouble();
System.out.println("Enter depth");
d=n.nextDouble();
System.out.println("Enter its distance from free water surface");
s1=n.nextDouble();
A=(0.5)*b*d;
h=(0.3333*d)+s1;
F=1000*9.81*A*h;
System.out.println("Area of rectangle=" +A+"m^2");
System.out.println("Its distance of C.G. from free surface="+h+"m");
System.out.println("Pressure force=" +F+"Newton");
I=(b*d*d*d)/(36);
h1=h+(I)/(A*h);
System.out.println("Moment of Inertia=" +I+"m^4");
System.out.println("Centre of pressure=" +h1+"metre");
break;
```

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**case 3:**

```
System.out.println("You have selected circular object");
System.out.println("Enter diameter of circle");
d=n.nextDouble();
System.out.println("Its distance between free water surface & its centre");
s1=n.nextDouble();
A=(0.78539816)*d*d;
h=s1;
System.out.println("Area of rectangle=" +A+"m^2");
System.out.println("Its distance of C.G. from free surface="+h+"m");
F=1000*9.81*A*h;
System.out.println("Pressure force=" +F+"Newton");
I=(0.04908)*d*d*d*d;
h1=h+((I)/(A*h));
System.out.println("Moment of Inertia=" +I+"m^4");
System.out.println("Centre of pressure=" +h1+"metre");
```

**break;**

**case 4:**

```
System.out.println("You have selected trapezoidal object");
System.out.println("Enter smaller side");
a=n.nextDouble();
System.out.println("Enter bigger side");
b=n.nextDouble();
System.out.println("Enter its distance from free water surface");
d=n.nextDouble();
A=0.5*(a+b)*d;
g1=((2*a)+b)/(a+b);
g2=d*0.3333;
g3=g1*g2;
F=9810*A*g3;
System.out.println("Area of rectangle=" +A+"m^2");
System.out.println("Its distance of C.G. from free surface="+g3+"m");
System.out.println("Pressure force=" +F+"Newton");
```

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```
i1=(a*a)+(4*a*b)+(b*b);  
i2=(36)*(a+b);  
i3=i1/i2;  
i4=(i3)*(d*d*d);  
h1=(i4)/(A*g3);  
h2=(h1)+g3;  
System.out.println("Moment of Inertia=" +i4+"m^4");  
System.out.println("Centre of pressure=" +h2+"metre");  
break;  
default :System.out.println("Enter between 1-4 only");  
}}}
```

## 2) Practical Problem

Statement: A heavy car plunges into a lake during an accident and lands at the bottom of the lake on its wheels (As shown in Fig) The door is 1.2 m high and 1 m wide, and the top edge of the door is 8 m below the free surface of the water. Determine the hydrostatic force on the door and the location of the pressure centre, and discuss if the driver can open the door.

### • Solution:

A car is submerged in water. The hydrostatic force on the door is to be determined, and the likelihood of the driver opening the door is to be assessed.

#### Assumptions

- 1) The bottom surface of the lake is horizontal.
- 2) The passenger cabin is well-sealed so that no water leaks inside.
- 3) The door can be approximated as a vertical rectangular plate.
- 4) The pressure in the passenger cabin remains at atmospheric value since there is no water leaking in, and thus no compression of the air inside. Therefore, atmospheric pressure cancels out in the calculations since it acts on both sides of the door.
- 5) The weight of the car is larger than the buoyant force acting on it.

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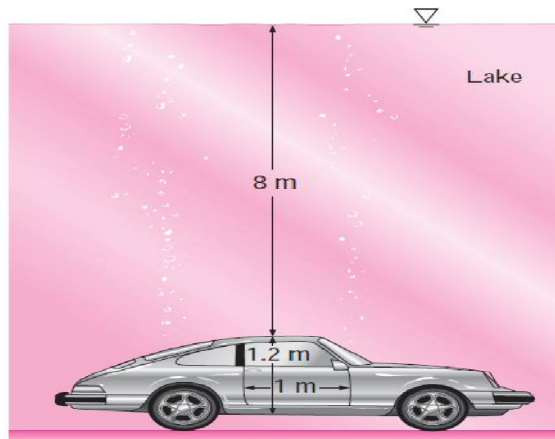


Fig.2 Practical Problem Representation

Source: Fluid Mechanics Fundamentals and Application by Yunus.A.Cengel, John. M. Cimbala.

### Analytical Results:

**Properties** We take the density of lake water to be  $1000 \text{ kg/m}^3$  throughout.

**Analysis** The average pressure on the door is the pressure value at the centroid (midpoint) of the door and is determined to be

$$\begin{aligned} P_{\text{ave}} &= P_C = \rho g h_C = \rho g (s + b/2) \\ &= (1000 \text{ kg/m}^3)(9.81 \text{ m/s}^2)(8 + 1.2/2 \text{ m}) \left( \frac{1 \text{ kN}}{1000 \text{ kg} \cdot \text{m/s}^2} \right) \\ &= \mathbf{84.4 \text{ kN/m}^2} \end{aligned}$$

Then the resultant hydrostatic force on the door becomes

$$F_R = P_{\text{ave}} A = (84.4 \text{ kN/m}^2)(1 \text{ m} \times 1.2 \text{ m}) = \mathbf{101.3 \text{ kN}}$$

The pressure center is directly under the midpoint of the door, and its distance from the surface of the lake is determined from Eq. 3–24 by setting  $P_0 = 0$  to be

$$y_P = s + \frac{b}{2} + \frac{b^2}{12(s + b/2)} = 8 + \frac{1.2}{2} + \frac{1.2^2}{12(8 + 1.2/2)} = \mathbf{8.61 \text{ m}}$$

Fig.3 Analytical results Calculated

Source: Fluid Mechanics Fundamentals and Application by Yunus.A.Cengel, John. M. Cimbala.

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### IV. EXPERIMENTAL RESULTS

Following results are obtained with the help of java programme for the practical problem given above.

```
Fluid Mechanics
This programe will tell us pressure force & centre of pressure
Enter 1 if your object is Rectangle
Enter 2 if your object is Traiangle
Enter 3 if your object is circle
Enter 4 if your object is Trapezium
1
You have selected rectangular object
Enter width
1
Enter depth
1.2
Enter its distance from free water surface
8
Its distance of C.G. from free surface=8.6m
Pressure force=101239.2Newton
Moment of Inertia=0.144m^4
Centre of pressure=8.613953488372093metre
```

### V. CONCLUSION

At the end of this project we came to conclusion that-

- 1) From above results we observed that the values obtained by manually as well as by using java Programme both are same. Hence above java programme can be used to calculate any problems related Hydrostatic force.
- 2) Centre of pressure (i.e.,  $h^*$ ) lies below the centre of gravity of vertical surface.
- 3) The distance of centre of pressure from free surface of liquid is independent of the density of the liquid.
- 4) The concepts of OOP's and Java are helpful for simplifying the numerical problems such as Fluid flow etc.

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