Assignment Front Sheet

Qualification		**Unit Number and Title**
Pearson BTEC International Level 3 Extended Diploma in Engineering		Unit 29: Principles and Applications of Fluid Mechanics
Unit Level		**Unit Type**
3		Optional
Reg. No. Learner's Name		**Assessor's Name**
		Ms. Maduri
Hand-out Date	**Hand-in Date**	**Submitted On**
September 26th, 2021	July 4 th,2022	July 4 th,2022

Assignment Type	Summative Report
Assignment Title	Understanding Principles and Applications of Fluid Mechanics

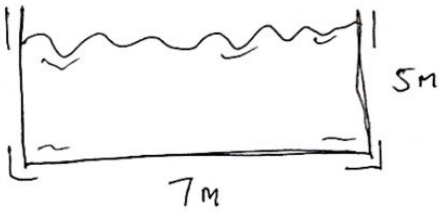
Learner's Declaration
I certify the work submitted for this assignment is my own and research sources are fully acknowledged. Learner's Signature: Muaaz Bilal Date: Acknowledged by: Assessor's Signature: Date:

Unit - 2 q
Muaaz

→ A storage tank is 7 meter wide. It contains a liquid with density 1000 kg/m³ to a dept of 5 meter. Calculate the hydrostatic thrust on the side of the tank, and it's position from surface of the liquid.

Ans:- Given: $d = 5m$
$w = 7m$

ρ water = 1000 kg/m³



$$\bar{y} = \frac{5}{2} = 2.5m$$

- Hydrostatic thrust - $(F) = \rho g [A\bar{y}]$

$$(F) = 1000 \times (9.81) \times (35)(2.5)$$

$$[F = 85837.5\ N]$$

Find (I_{gg}) moment of Interia in center of gravity Eq.

$$I_{gg} = \frac{BD^3}{12}$$

$$I_{gg} = \frac{7 \times 5^3}{12}$$

$$[I_{gg} = 72.91]$$

$$I_{SS} = I_{gg} + A\bar{y}^2$$

$$72 + (35)(2.5)$$

$$[I_{SS} = 159.5\ m^4]$$

$$\bar{h} = \frac{I_{SS}}{A\bar{y}} = \frac{159.5}{35 \times 2.5} =$$

$$[\bar{h} = 1.82 \text{ meters}]$$

Unit - 29
LA-C

1) A rocket has a total lift-off mass of 2×10^6 kg. 80% of the mass is the propellant fuel. The rocket consumes fuel at a rate of 4×10^3 kg/s and the exhaust gases have a constant velocity of 8 km/s

Calculate:

a) the time for all the fuel to be used
b) the thrust produced
c) the net force on lift-off
d) the initial acceleration.

Ans =>

Total mass = 2×10^6 kg (m)

Mass of propellent = $\frac{80}{100} \times 2 \times 10^6 = 16 \times 10^5$ kg

Fuel mass of flow rate = 4×10^3 kg/s

Velocity of exhaust gases = $\frac{8 \text{ km}}{5} = \frac{8000 \text{ m}}{5}$

a) Time for power fuel to be used = $\frac{\text{Mass of propellent fuel}}{\text{Fuel mass flow rate (consuption rate)}}$

$= \frac{16 \times 10^5}{4 \times 10^3} = 400$ seconds

b) thrust produced = $m \times V_{ex}$

$= 4 \times 10^3 \times 8000 = 32 \times 10^6$ N/s

c) Net force on lift off = T - W

T = 32×10^6, W = mxg = $(2 \times 10^6 \times 9.81)$

T-W = $32 \times 10^3 - (2 \times 10^6 \times 9.81)$

$= 32000000 - 19620000$

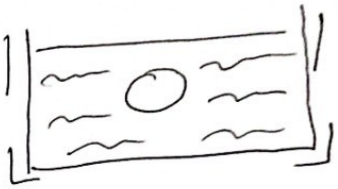
$= 1.23 \times 10^5$ N

A ball of ~~steel~~ mass 10 kg and diameter 2 meter is held fully under water (density 1000 kg/m³) Calculate the upthrust and density of ball.

Given -

$m = 10\ kg$

$r = \frac{2}{2} = 1\ m$



→ Finding the upthrust

upthrust $= \rho g v$

$V = \frac{4}{3}\pi r^3$

$V = \frac{4}{3}\pi \times 1^3$

$V = 4.18\ m^3$

$F = \rho g v$

$F = 1000 \times (9.81) \times 4.18$

$F = 41031.6\ N$

$F = 41031.6\ N$

Now we will find the density of the ball

$\rho_b = \frac{mass}{volume}$

$\rho_b = 10 / 4.18$

$\rho_b = 2.39\ kg/m^3$

$\rho_b = 2.07\ kg/m^3$

A journal runs in a bearing diameter, 25 mm and length 100 mm at 25 rev/sec. The clearance gap is 0.8 mm. The dynamic viscosity of 80 cP. The bearing must carry a side load of 800 N. Calculate the values of

→ Friction force
→ coefficient of friction.

> Given

D = ~~Diameter~~ 25 mm = 0.025

L = 100 mm = 0.1

N = 25 rev/s

C = 0.8 mm = 0.0008

η = 80 cP = 80×10^{-3} = 0.08 Pa·s

R = 800 N = 800×10^{-3} kN

Frictional force = $\frac{\eta D^2 \pi^2 N L}{C}$

= $\frac{0.08 \times 0.025^2 \times \pi^2 \times 25 \times 0.1}{0.8 \times 10^{-3}}$

= 1.54 N

Coeff of friction = $\frac{\eta \pi^2 L N D^2}{C \cdot R}$

= $\frac{0.08\ \pi^2 \times 0.1 \times 25 \times 0.025^2}{0.0008 \times 800 \times 10^{-3}}$

= 1.23

The manometer contains water (density 1000 kg/m³). Calculate gauge pressure if the head is 250 mm. Atmospheric pressure at sea level = 101325 Pascals.

Given :-

$\rho_{water} = 1000\ kg/m^3$ $\quad h = 250\ mm = 0.25\ m$

$P_{atm} = 101325$ pascals

$P_{gauge} = \rho g h$

$= 1000 \times (9.81) \times 0.25$

$= 2452.5\ Pa$

Absolute gauge or P absolute

$= P_{atm} + P_{gauge}$

$= 101325 + 2452.5$

$[= 103777.5\ Pa]$

A simple hydraulic jack has a pump piston diameter 10 cm, and a load piston 100 cm. Calculate.

→ the effort force needed to lift a load of 750 Newton

→ The distance moved by the load if the effort moves a distance 10 cm

Given -

$D_1 = 10\ cm = 0.1\ m$

$D_2 = 100\ cm = 1\ m$

$F_2 = 750\ N$

-Force ratio formula-

$$\frac{F_2}{F_1} = \frac{A_2}{A_1}$$

Circle cross section formula

$$\frac{\pi}{4} d^2$$

$$\frac{F_2}{F_1} = \frac{\frac{\pi}{4} D_2^2}{\frac{\pi}{4} D_1^2} \Rightarrow \frac{750}{F_1} = \frac{1^2}{0.1^2}$$

$$\Rightarrow \frac{F_1}{750} = \frac{0.1^2}{1^2} \times 750$$

$F_1 = 7.5\ N$

-Distance moved-

$$\frac{F_2}{F_1} = \frac{X_1}{X_2}$$

$$\frac{750}{7.5} = \frac{10}{X_2}$$

$$X_2 = \frac{7.5 \times 10}{750}$$

$$X_2 = 0.1\ m$$

0.5 kg of gas is heated from 50°C to 100°C. The gas at constant volume is 0.72 kJ/kgk and the specific heat capacity at constant pressure 1.01 kJ/kgk.

Calculate the change in.

-> Enthalpy

-> Internal change

-Given -

$M = 0.5\ kg$

$1C^\circ = 273$

$T_1 = 50°c = 50 + 273 = 323$

$T_2 = 100°c = 100 + 273 = 373$

$C_v = 0.72\ kJ/kgk$

$C_p = 1.01\ kj/kgk.$

Calculating enthaply

$mC_p(T_2 - T_1)$

$= 0.5 \times 1.01 \times (373 - 323)$

$[= 25.25\ kJ.]$

calculating Internal energy

$mC_v(T_2 - T_1)$

$= 0.5 \times 0.72 \times (373 - 323)$

$[= 18\ kJ.]$

$0.8\ m^3$ of the gas at a pressure of 1 bar is compressed to $0.4\ m^3$ in an adiabatic change. Calculate the.

→ Ratio of specific heat capacities
→ final pressure.

Given -:

$V_1 = 0.8\ m^3$

$P_1 = 1$ bar

$V_2 = 0.4\ m^3$

$C_v = 0.72\ kJ/kgk$

$C_p = 1.01\ kj/kgk.$

$$\gamma = \frac{C_p}{C_v}$$

a) $\frac{C_p}{C_v} = \frac{1.01}{0.72} = 1.4$

$[\gamma = 1.4]$

b) $P_V^{\gamma} = C$

$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$

$1 \times 0.8^{1.4} = P_2 \times (0.4)^{1.4}$

$$P_2 = \frac{1 \times (0.8)^{1.4}}{(0.4)^{1.4}}$$

$[P_2 = 2.63\ bar]$

Q7 A rocket has a total lift-mass of 2×10^6 kg. 20% of the mass is the propellant fuel. The rocket consumes fuel at a rate of 4×10^3 kg/s and the exhaust gases have a constant velocity of 8 km/s. Calculate.

a) the time for all the fuel to be used

b) the thrust produced

c) the net force of lift-off

d) the initial acceleration.

You should evaluate:

Evaluate how fluid linear momentum principles are applied to.

B) the optimised operation of the pelton impulse hydraulic turbine

f) gas turbine engine.

Given:-

$M_R = 2 \times 10^6$ kg $\quad M_f = (2 \times 10^6) \times 0.8$

$= 1.6 \times 10^6$ kg.

Fuel mass flow rate $= 4 \times 10^3$ kg/s

Velocity of gasses $V_g = 8$ km/s

$= 800$ m/s^{-1} that will be 8×10^{-3} m/s^{-2}

a) time for the fuel to be used.

$$\frac{m_f}{m\dot{r}_f} \Rightarrow \frac{1.6 \times 10^6}{4 \times 10^3} \quad \frac{kg}{kg/s}$$

$\Rightarrow 0.4 \times 10^3$

$\Rightarrow 400$ seconds

b) thrust produced : - impulse momentum theorem

=> $4 \times 10^3 (8 \times 10^3)$

=> $32 \times 10^6 \ N/s^{-1}$

- Formula -

$mfR \times Vg$

c) The net force of lift off:

$g = 9.81 \ ms^{-2}$

- formula -

$W = mg$

$W = 2 \times 10^6 (9.81)$

$= 19.62 \times 10^6 \ N$

Newton's second law, Net force =>

=> Thrust (b) weight (w)

- Formula -

Thrust (b) - weight (w).

$32 \times 10^6 - 19.62 \times 10^6$

$12.4 \times 10^6 \ N$

Intial acceleration

$$a = \frac{12.4 \times 10^6}{2 \times 10^6}$$

$a = 6.2 \ ms^{-2}$

Gases are substance that move freely around and can capture on any shape. Moreover, they are easy to compress, and they expand to fill the container on any shape as gases are free molecules, so they don’t have any kind of shape. Moreover, gases are low in density as they contain disband molecules that vanish across a given volume. In addition, the diffusion rate of gas is very fast.

Liquids are free moving molecule that captures any container of any shape. Moreover, the liquid has no fixed shape but a definite volume. Primarily, the liquids diffusion rate is fast. Additionally, the particles are free to move over each other. Fluid power is a term that describe hydraulics and pneumatics. Each machine uses a fluid such as liquid and gas to convey power from one place to another. Moreover, the hydraulics is a liquid and pneumatics uses gas.

Hydrostatic principles are used for clearing problems linked to pressure in deep water, primarily the pressure of the water expands due to the depth. Moreover, the principle of hydrostatic fluid is that the pressure put in the surface of fluid will be conveyed in a consistent form through all paths, in a way that initial variation in pressure is exchanged. Pneumatic fluids are same as hydraulics, additionally pneumatic fluid persuades energy using gas instead of liquid.

Hydralic system

Gases have two heat capacities because gases aren’t stable like solid or liquid, primarily when the volume has been held stable, primarily that’s why we get heat storage at constant volume.

Specific weight - weight of per unit volume of an element is the precise weight, occasionally it called as unit weight. The specific mass of the water on Earth at 5 °C, which is 8.807 kilonewtons per cubic metre or 62.43 pounds-force per cubic foot, is often castoff extent.

Formula for specific weight

$$\gamma = \rho g$$

Specific Gravity -The ratio of a substance's density to the compactness of a certain position objects are known as its virtual density or precise gravity. For gases, the reference is air at room temperature, whereas liquids are almost generally measured in relation to the densest possible form of water.

$$RD = \frac{\rho_{\text{substance}}}{\rho_{\text{reference}}}$$

RD = relative density

$\rho_{\text{substance}}$ = density of the substance being measured

$\rho_{\text{reference}}$ = Density of the reference

Capillarity - Capillarity is the term used to describe this phenomena of rising or falling liquid levels in capillary tubes. Cohesion and adhesion are the causes of capillarity. water molecules, the liquid will soak the surface of the glass and the liquid level will rise. As seen in, the liquid level will develop an upward concavity.

$$h = \frac{2T\cos(\theta)}{pgr}$$

Where

h =elevation of the liquid[m]
T = surface tentiion [Nm^{-1}]
θ = angle of contact 9f the liquid with the capillary tube [radians]
p = density of the liquid [kgm^{-3}]
g = standard acceleration due to gravity [ms^{-2}]
r = radius of capillary tube [m]

Surface tension - Exterior pressure is the tendency for liquid surfaces that are at stationary to abridge into the least surface zone. Razor blades and creatures, which have a mass greater than liquid, may float on the surface of the liquid minus level of receiving partly suppressed because to the surface tension.

Formula

$$\gamma = \frac{1}{2} \cdot \frac{F}{L}$$

γ = surface tension

F = force

L = length

Mass density - The proportion of a fluid's mass to volume is known as the fluid's mass density or density. A fluid's density is known as the mass per unit volume.

Formula

$$\rho = \frac{m}{V}$$

ρ = density

m = mass

V = volume

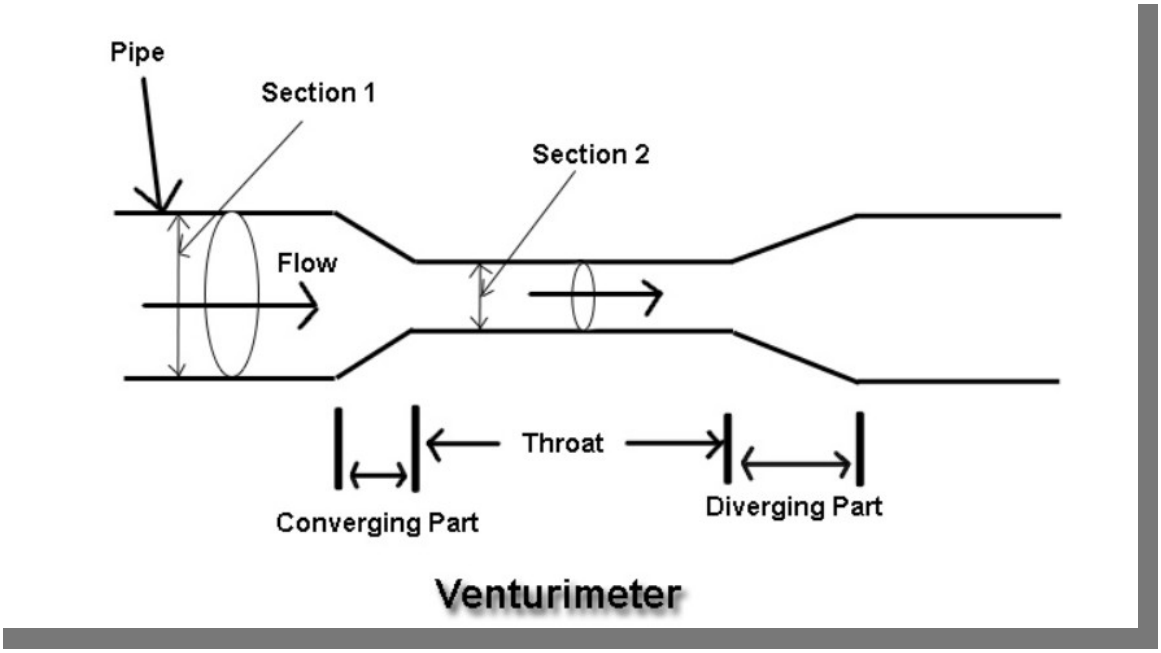
Difference Between Isothermal and Adiabatic process

Isothermal	Adiabatic
Conveys of heat occurs	No Transfer of heat occurrences
Pressure is high at a given volume	Pressure is less at the given volume
temperature is constant	Temperature keeps on changing due to the internal system variations.
Heat can be added or released into the complex to maintain a consistent temperature.	There is no heat input or heat release since keeping a consistent temperature is not important here.
The conversion is slow	The conversion is fast

Bernoulli's equation may be thought of as a law of conservation of energy for a flowing fluid. Bernoulli's equation can arose from the fact that any excess kinetic or potential energy obtained by a fluid system is produced by external work done on the system by another non-viscous fluid.

Venturi meter

As the cross-section from the input pipe to the throat narrows, the fluid's velocity increases and the pressure decreases. The pressure drop causes a pressure difference to form between the venturi meters throat and the intake pipe. The basic idea behind a venturi metre is based on the Bernoulli equation, which declares that when velocity rises the, pressure goes down. The throat's cross section is lower than the input pipe's cross section. Additionally, when the fluid moves from the input pipe to the throat, its velocity-rate increases, and the pressure lowers as a result.



Covering part: covering part is where the portion of the fluid joins.

Throat: It's the part of the venturi that's in between the convergency and deviating parts. The cross section of the neck is substantially smaller than the converging and diverging portions. The velocity of the rises as it approaches the neck, but the pressure lowers.

Diverging part: The fluid departs, so the cross-section area increases in this region of the venturi metre.

Formula for venturi meter

$p_{1-¿¿}\ p_2 = \frac{p}{2}\left(v_2^2 - v_1^2\right)$

p_1= pressure at position 1 before the narrowing of the pipe

p_2= pressure at position 2 after the narrowing of the pipe

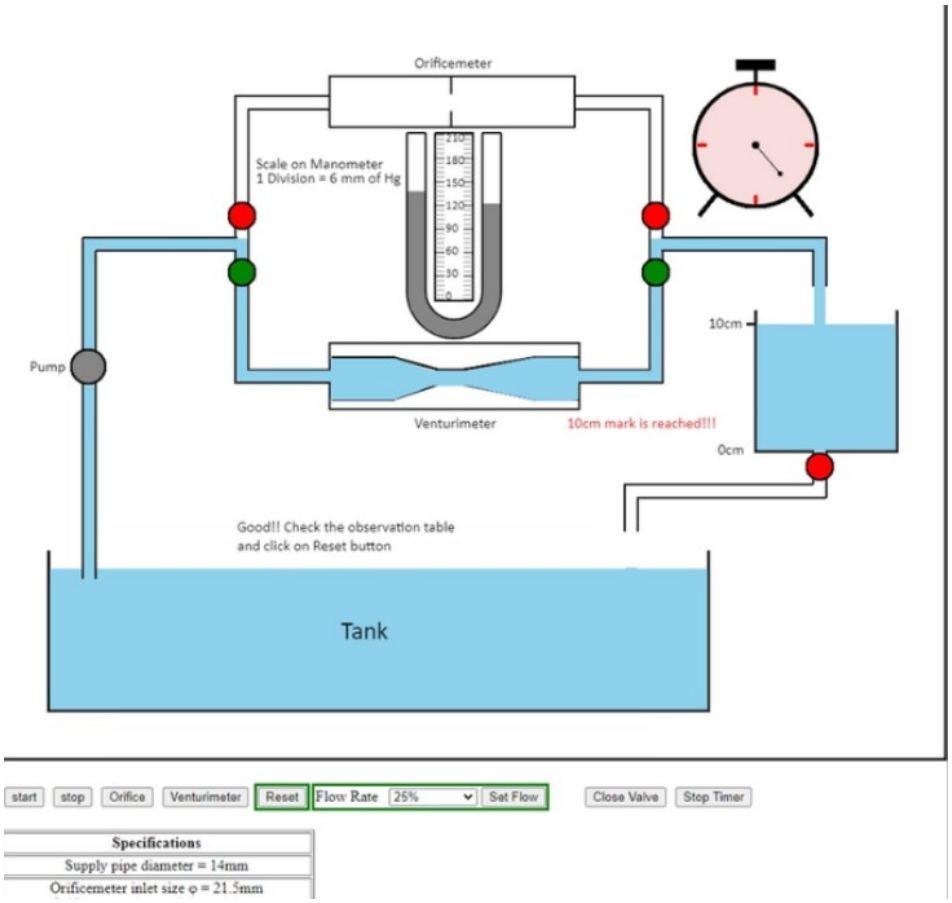
$\frac{p}{2}$= density of the fluid traveling in pipe

v_2^2= velocity of the fluid at position 2

v_1^2= velocity of the fluid at position 1

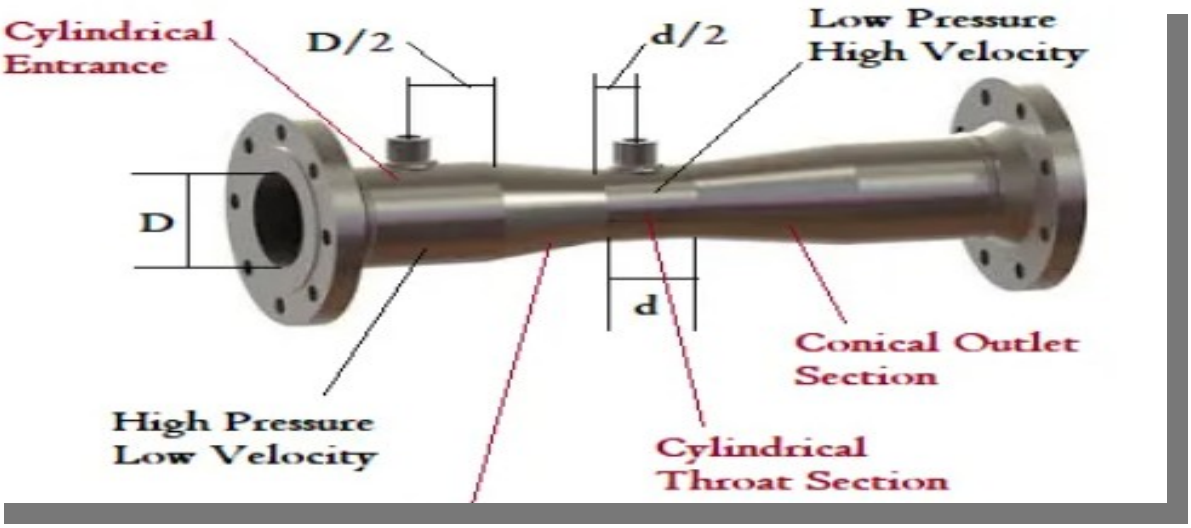
Area of the measuring tank = 0.12m^2
Diameter of the venturi meter at the inlet (D) = 25mm
Diameter of the throat = 12.5 mm
Head = 13.6h

Actual Discharge (m^3/sec)	Pressure difference (h)	Time taken to rise 10 cm	Q $_{Theoretical}$	Coefficient of discharge (C_d)
0.0032	35	37	0.0032	0.94
0.0043	54	27	0.0044	0.96
0.005	73	22	0.0055	0.97
0.006	81	19	0.0061	0.98



Orifice meter

An orifice metre is a appliance with a hole in it that measures how fast the pressure drops across the hole to regulate how rapidly a fluid is going forward. The size and diameter of the pipe that an orifice metre is placed into are the two most important criteria that determine the reading of the instrument. The liquid or gas is passed through the orifice plate while the flow rate is considered. There is a pressure differential between the inlet and exit parts because of a compression bead that forms across the orifice plate channel and fluctuates with flow rate.



Cylindrical Entrance Section: To peruse to the Venturi metre is a liner cylindrical segment that is five to nine times the pipe width in extent.

Convergence Conical Section: Width of venturi metre tube steadily goes down at this segment. Usually, the conical angle is 210 20. And the liquid passes through the venturi metre, the velocity of the fluid rises when the pressure reduces.

Cylindrical Throat: The neck is where you'll find the smallest venture metre diameter. The neck region has the highest speed and the little pressure. The throat width typically ranges from 1/3 to 1/4 of the input pipe's width.

Diverging Conical section: This part of the venturi metre has a constantly increasing tube diameter. The pressure is subsequently returned to the initial intake pressure as a result. Cone angle ranges from 5 to 70 degrees. British Standard BS-1042 specifies two conical angles for the output cone: 5-70 and 14-150.

Formula for orifice meter

$$q_{m=\frac{C_d}{\sqrt{1-B^4}}\epsilon\frac{\pi}{4}d^2\sqrt{2\triangle p * p_1}}$$

qm= orifice plate flow rate

C_d= coefficient of discharge

β= diameter ratio of orifice diameter to pipe diameter

ϵ= expansibility factor

π= pi

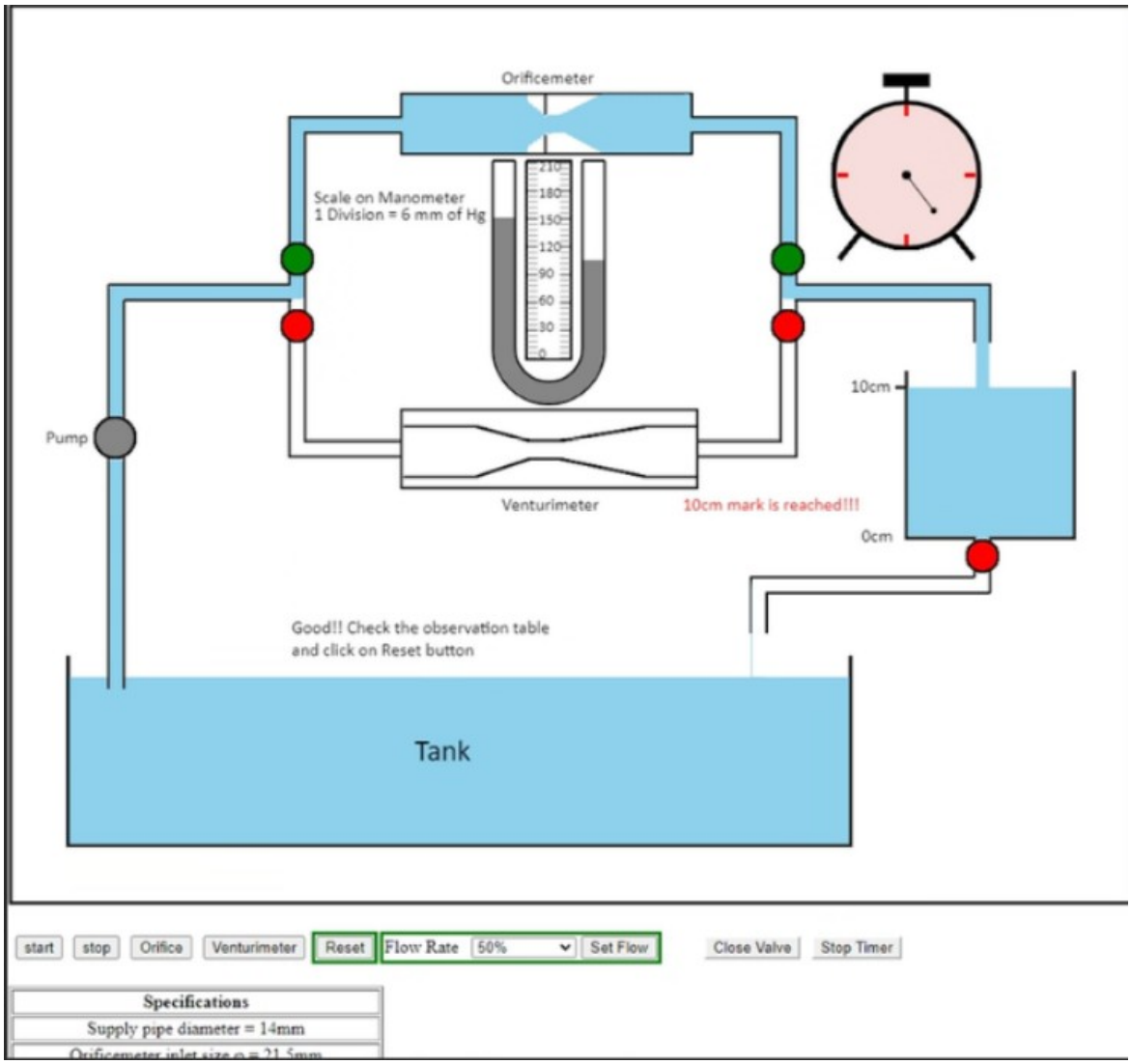
d= internal orifice diameter

Δp= differential pressure

p= fluid density

Orifice meter
Area of the measuring tank = 0.12m^3
The diameter of the orifice meter at the inlet (D) = 25mm
Diameter of the orifice = 12.5 mm
Head = 13.6h

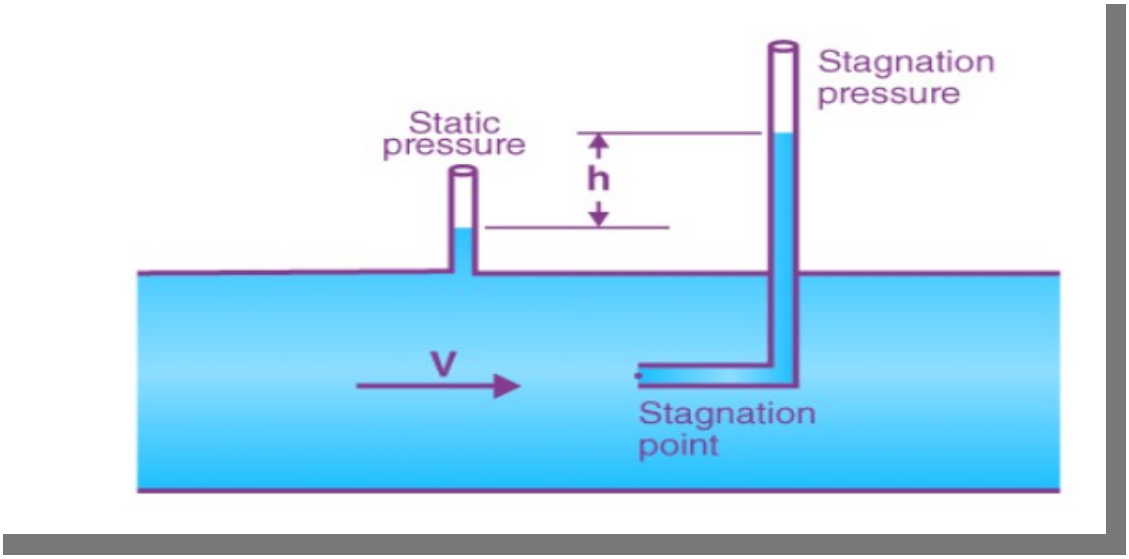
Actual Discharge (m^3/sec)	Pressure difference (h)	Time taken to rise 10 cm	$Q_{Theoretical}$	Coefficient of discharge (C_d)
0.00423	104	29	0.00655	0.64
0.00521	145	22	0.00804	0.63
0.0063	209	21	0.00926	0.61
0.00664	219	17	0.01028	0.66



Pitot tube

Pitot tubes are tubes that are used to gauge flow rates. A second measurement of static pressure is necessary since the pitot tube positioned in the flow stream only calculates the pressure at the contact pitot turn hole . Calculating dynamic pressure involves comparing the two

values and finding the difference.



Pitot tube formula

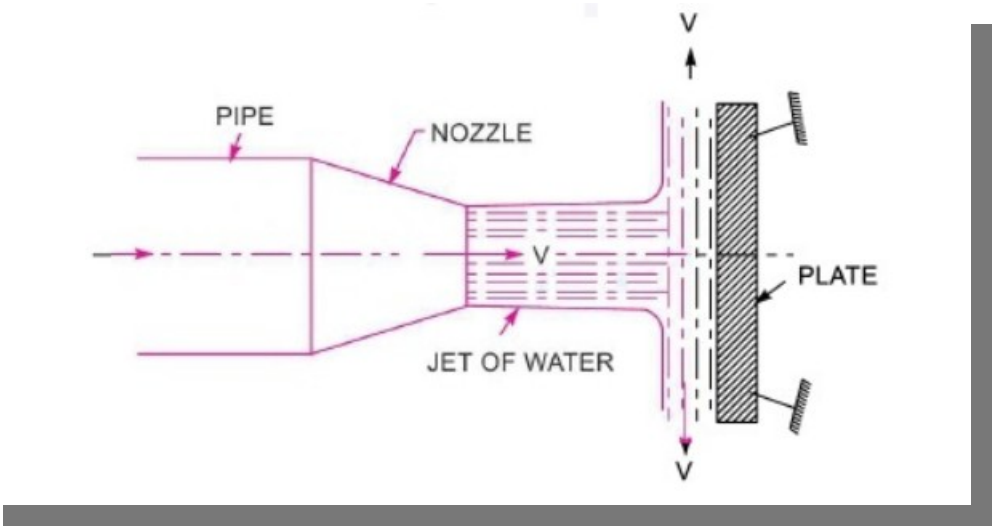
V = (2ΔP/ρ)1/2.

Fluid jet

Jet is the convection of fluid that passes through the nozzle into and ambient fluid of different velocity. Moreover, the use of nozzle is to increase the speed of the jet, primarily if the environment ambient fluid is stationary then the jet is called free jet.

For finding the water jet reaction force, multiply the velocity of the water by the mass flow rate.

Jet on a stationary vertical flat plate



$$F_x = \frac{rate\ of\ change\ of\ momentum \in the\ direction of\ force}{time}$$

$$= \frac{intial\ momentum - final\ momentum}{time}$$

$$= \frac{mass}{time} \text{ x } change \in velocity \in the\ direction\ of\ jet$$

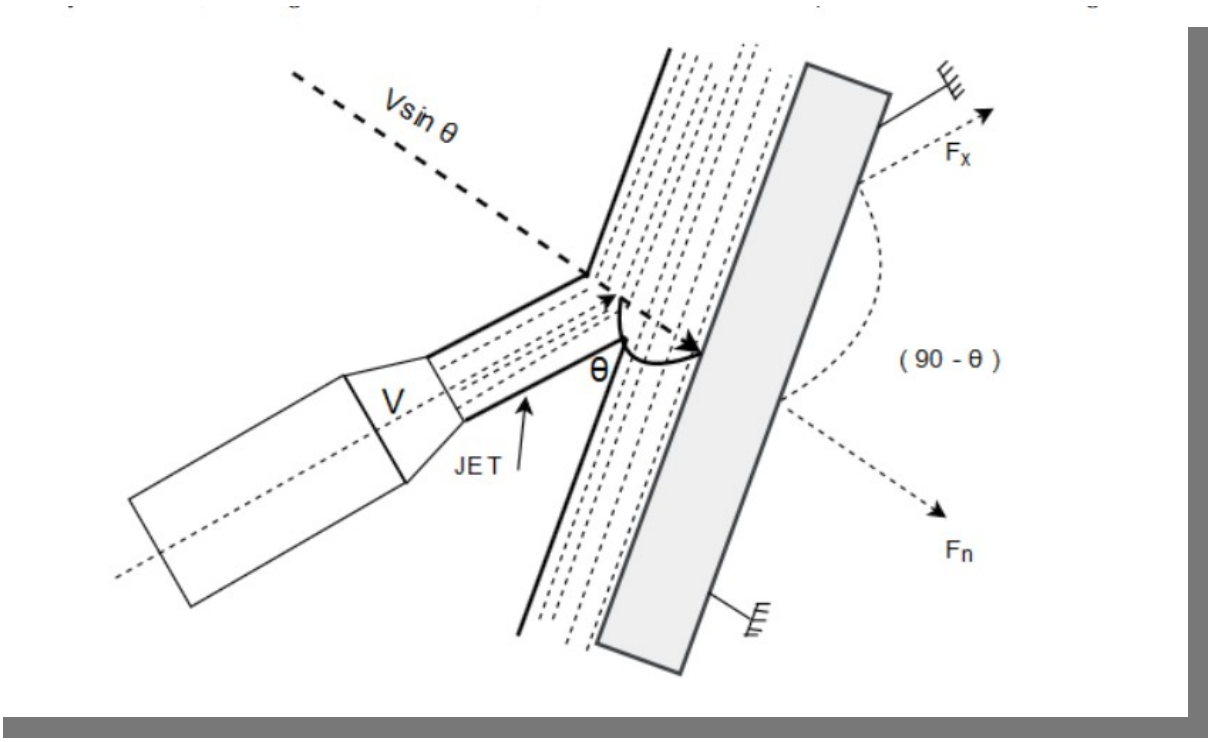
$= \frac{mass}{time}$ x [initial velocity of jet before striking in the direction of jet – final velocity of jet after striking in the direction of jet]

$$= m * \Delta V$$

$$= paV[V - 0]$$

V = velocity of jet
d = diameter of jet
a = area of c/s of the jet
ρ = density of fluid
Q = volume flow rate of fluid
$\dot{m}$ = mass flow rate of fluid = ϱQ = ϱav

Force exerted by the jet on a stationary inclined flat plate



F_n =*Mass of jet striking sec*x

$[$*initial velocity of jet striking*$\in$*the direction of* $n-$*final velocity of jet after striking*$\in$*the direction of* $n]$

$F_n = paV[V\sin\theta - 0]$

$F_n = paV\sin\theta$

V= velocity of jet in the direction of x

θ=angle between the jet and plate

Gas turbine- Gas turbine is a burning machine at the core of a supremacy plant that has ability for natural gas or additional fluid fuels to powered energy. This energy then peruses an originator that produces the electrical energy that changes lengthwise power lines to offices and homes. Energy conversion efficiency for a single cycle gas turbine can range from 20 to 35 percent. Future hydrogen and syngas powered gas turbine combined cycle plants are projected to achieve efficiencies of 60 percent or more because to the higher temperatures attained in the Department of Energy's turbine programme. Moreover, to add impulse momentum principle can be applied when the turbine rotates because of the powerful force created when the water jet hits the blade at maximum speed. The jet's velocity and time interval when it contacts the blades determine the force.

Gas turbine	$C_{t,g} = (\frac{c_{31}\dot{m}_g}{c_{32} - \eta_{t,g}}) \ln(\frac{P_3}{P_4})(1 + \exp(c_{33}T_3 - c_{34}))$

Pelton wheel- A hydro turbine (more precisely, an impulse turbine) known as a Pelton turbine or Pelton wheel is one that is widely employed in hydroelectric projects. Typically, locations with heads more than 300 metres employ these turbines. Lester Pelton invented this kind of turbine during the 1880s gold rush. Primarily, the pelton wheel turbine tangential convesion of urging turbine used in big heads of water. Kinetic energy is the only type of energy present at the turbine's inlet. At the turbine's inlet and outflow, there is air pressure energy. This is a hydraulic turbine, and hydropower plants typically use them to produce energy. impulse momentum is applicable as contrast to the conventional overshot water wheel, the Pelton wheel draws energy from the momentum of the moving water.

Impulse momentum principle- According to the impulse-momentum theorem, an object's change in momentum equals the impulse that was delivered to it. The equivalent of Newton's second law of motion, the impulse-momentum theorem. A vector quantity called momentum has the same direction as an object's velocity. Impulse is the result of multiplying the amount of force by the application time. The direction of the force and the vector amount of the impulse are same. The units for both momentum and impulse are kg m/s.

$$a = \frac{F_{net}}{m} \quad \Rightarrow \quad F_{net} = ma$$

$$a = \frac{\Delta v}{\Delta t}$$

Fire hose- fire hose is used for high pressure water supply when there is a disaster. Moreover, they have numerous hose varieties made especially for the fire sector. Discharge hoses, such as attack hose, supply hose, relay hose, forestry hose, and booster hose, are made to work under positive pressure. Suction hoses are those created to function under negative pressure.

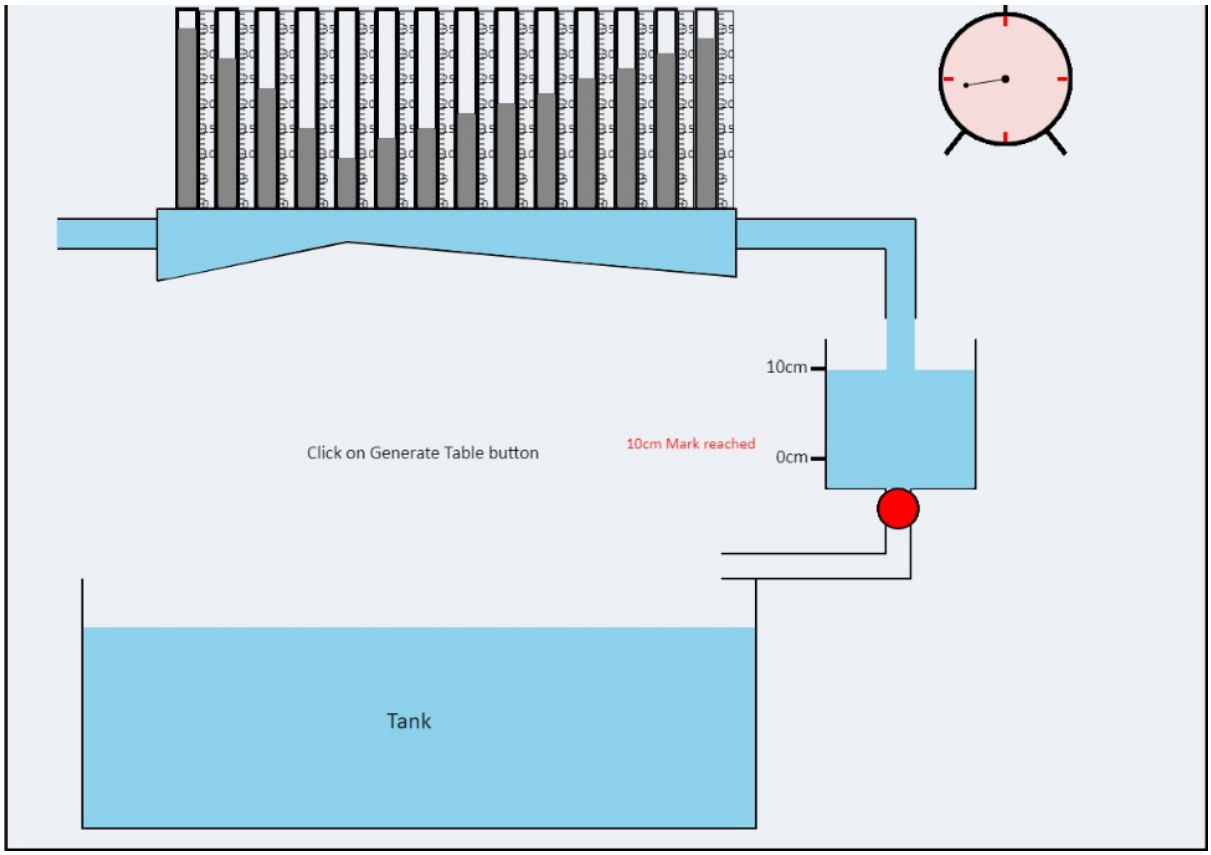
Rocket propulsion- the energy consumed by the rocket to launch into the atmosphere from the ground. The third law of motion by Newton forms the basis of the rocket propulsion principle. Here, the fuel is expelled from the exit aggressively to cause an equal and opposite reaction. Primarily, there are types many types of rocket propulsion such as, Solid rocket

motors, Hybrid rocket motors, Electrical Thruster and more. impulse momentum is applicable when the motion of a rocket that accelerates in the opposite direction of the velocity of the expelled fuel by ejecting burned fuel gases, changing its velocity (and hence its momentum).

Formula

Δ v = u ln (m i m)

Tapered pipe



Tapping Position	Diameter of the section (mm)	Manometer Height (cm)
A	25	31.3

B	15	27
C	13	26
D	10	28
E	10.8	24
F	16	23
G	24	34

Summary

We learned about different formulas and by using them we calculated mass initial velocity and angle of defection. Them we summarised about each method.

Bibliography

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(Boyce A., 2010), (2010) BTEC Level 3 National Engineering Student Book (Level 3 BTEC National Engineering),