Expt. No. 01 [120BM0014] Date 17/01/2022

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VERIFICATION OF BERNOULLI's THEOREM.

Aim: To verify that in a pipe flow if the incompressible fluid flows then it will be the sum of the terms in Bernoulli's equation and the total head will be constant at all point using piezometer tubes

Apparatus Required :-

→ A tank to supply water
→ Measuring Tank
→ A tappered pipe fitted with piezometer tubes
→ Stop Watch.

THEORY

Bernoulli's equation uses the principle of conservation of Energy to study about fluid flow. It tells us that in a steady flow, non-viscous fluid and the flow is irrotational, the aim of the potential head, pressure head and Kinetic head is same at all points.

The Bernoulli's equation can be expressed as:-

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

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where,

P = Pressure (N/m^2)

ρ = density of the fluid. (kg/m^3)

g = gravity / acceleration due to gravity (m/s^2)

v = fluid velocity (m/s)

Z = vertical elevation of the fluid. (m)

So actual discharge, $Q_{ac} = \frac{a \times H}{t}$ m^3/s

a = area of the tank (m^2)

H = height difference of the water column (m)

t = time taken to rise H meter (sec)

Velocity of flow at A is, $V = \frac{Q_{AC}}{A_a}$

Velocity Head, $H_{va} = \frac{V_a^2}{2g}$

Pressure Head, $H_p = \frac{P}{\rho g}$

Rate of flow $Q = \frac{V}{t}$ → Volume, → time

As, the height or elevation(z) is constant everywhere because of horizontal pipe, so, we can conclude that at a single point of cross section.

Pressure Head (H_p) + Velocity Head (H_v) = constant.

PROCEDURE

* Note down the values of area of the cross section of collecting tank and dimensions of convergent and divergent ducts.

* Adjust the flow of outlet and inlet valve to make the head constant in supply tank. At the constant head, causing

* Note down the readings of the water level of each piezometer tube which are nothing but pressure heads at different points of tapered tube.

* Calculate the Rate of flow from the quantity of water collected and time taken to collect the amount of water.

* Change the flow rate to repeat the experiment.

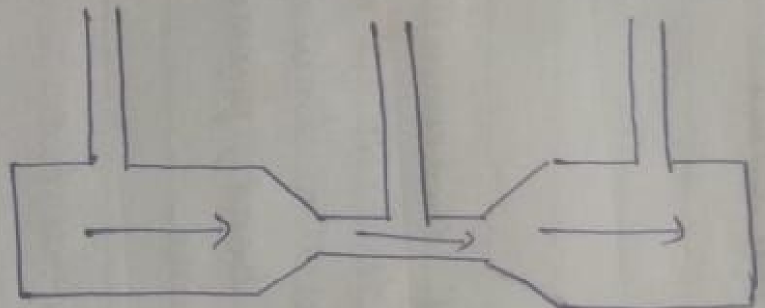
CALCULATIONS

Volume of Water collected = $a \times H$

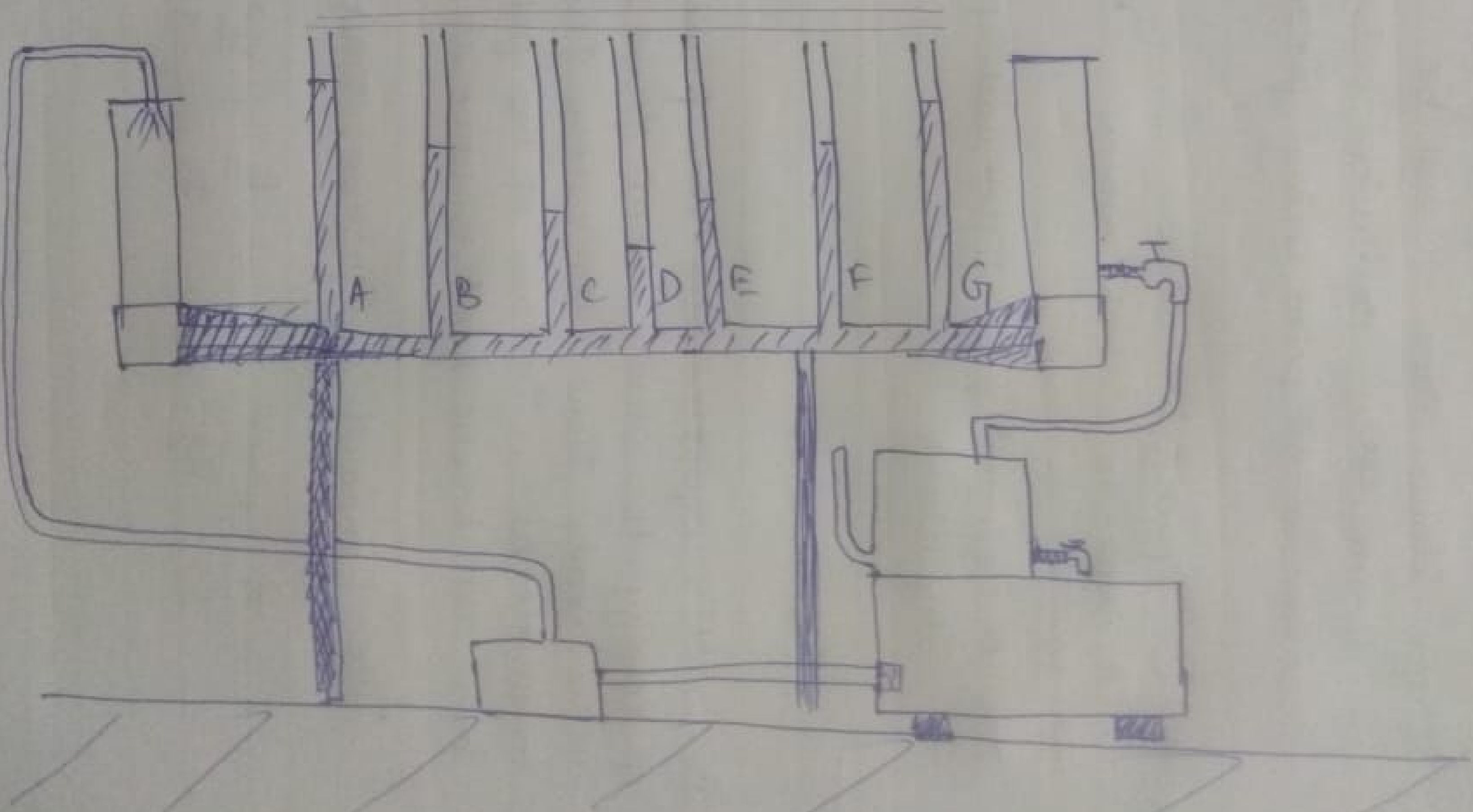
Discharge $Q = \frac{V}{t}$ Velocity flow = $\frac{Q}{A}$

Velocity head = $V^2/2g$

Total head = $\frac{P}{\rho g h} + \frac{V^2}{2g} = \left(h + \frac{V^2}{2g} \right)$



(Bernoulli's Apparatus)



SNo	Head H (cm)	Head cm	Time for collecting Vm^3 of water in Tank (sec)	Duct NO	Area A m^2	Velocity $= \frac{Q_{a}}{A}$ (m/s)	Velocity Head $V^2/2g$ (m)	Pressure Head m	$H_p + H_v$
1	High	22.3	60	1	0.394	0.81	0.033	0.223	0.256
		21.6		2	0.176	1.12	0.064	0.216	0.279
		16.6		3	0.109	1.21	0.1607	0.166	0.333
		8.9		4	0.098	2	0.203	0.089	0.292
		8		5	0.109	1.81	0.167	0.080	0.247
		13.6		6	0.176	1.12	0.064	0.136	0.200
		15		7	0.394	0.5	0.012	0.15	0.162
2	Low	27.5	60	1	0.394	0.25	0.0032	0.275	0.278
		27.7		2	0.176	0.56	0.016	0.277	0.232
		27		3	0.109	0.895	0.8	0.270	0.350
		26.2		4	0.0985	0.99	0.98	0.262	1.242
		26		5	0.109	0.895	0.8	0.26	1.06
		26.1		6	0.176	0.56	0.015	0.361	0.276
		26.3		7	0.394	0.25	0.[illegible]	0.263	0.266

RESULT

The Bernoulli's Equation is verified and the variation in total head is due to frictional loss.

PRECAUTION

-> Discharge should be kept constant throught observation
-> Depth should be observed.

DETERMINATION OF MOMENT OF FORCE AT VARIOUS ANGLES OF BICEP MUSCLE AND TO CALCULATE ITS MECHANICAL ADVANTAGE.

Aim :- To determine the moment of force at various angles of bicep muscle and to calculate its mechanical advantage.

Apparatus required :-

i) A set of free weights
ii) Protractor
iii) Scale.

THEORY

The equation related to finding the moment of force –

$$M \times M_A = R \times R_A$$

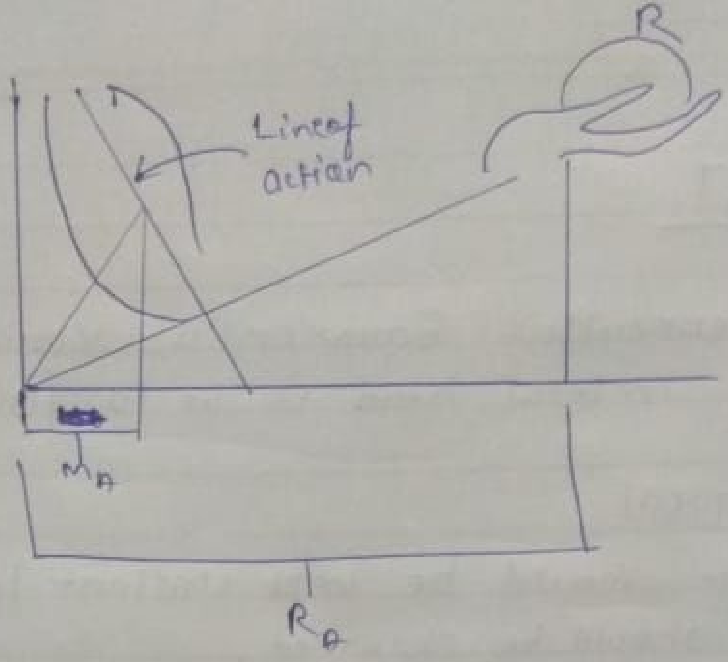
M = moment of force (or) torque

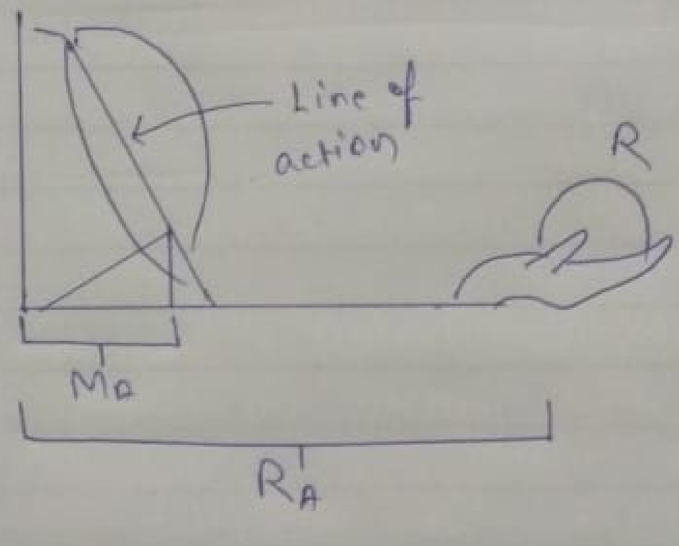
M_A = its the movement arm or the perpendicular distance from line of action.

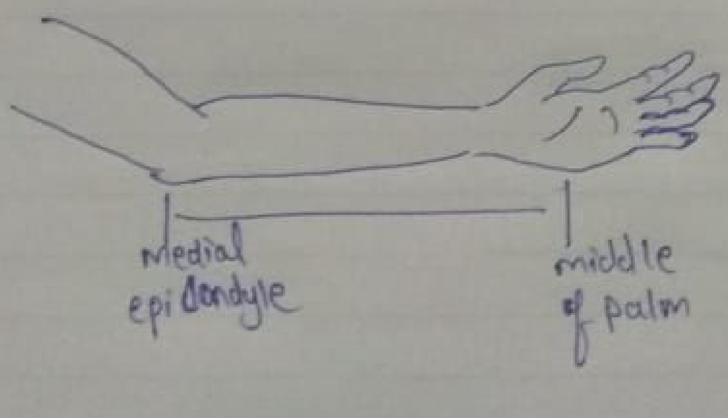
R = Resistance force / Load to be lifted.

R_A = it is the perpendicular distance from the load.

M_A is 2.54 cm from the elbow to the insertion and 5 cm from elbow for females and males respectively at 0° angle.


R
Line of action
M_A
R_A


Line of action
R
M_A
R_A


medial epicondyle
middle of palm

R_A, at an angle of 0° is the length of the forearm. At other angles both R_A & M_A changes.

- The movement of the elbow joint is uni-directional and provide more stable force and less injury. Whereas due to multiple rotation quality of shoulders it can easily get injured.

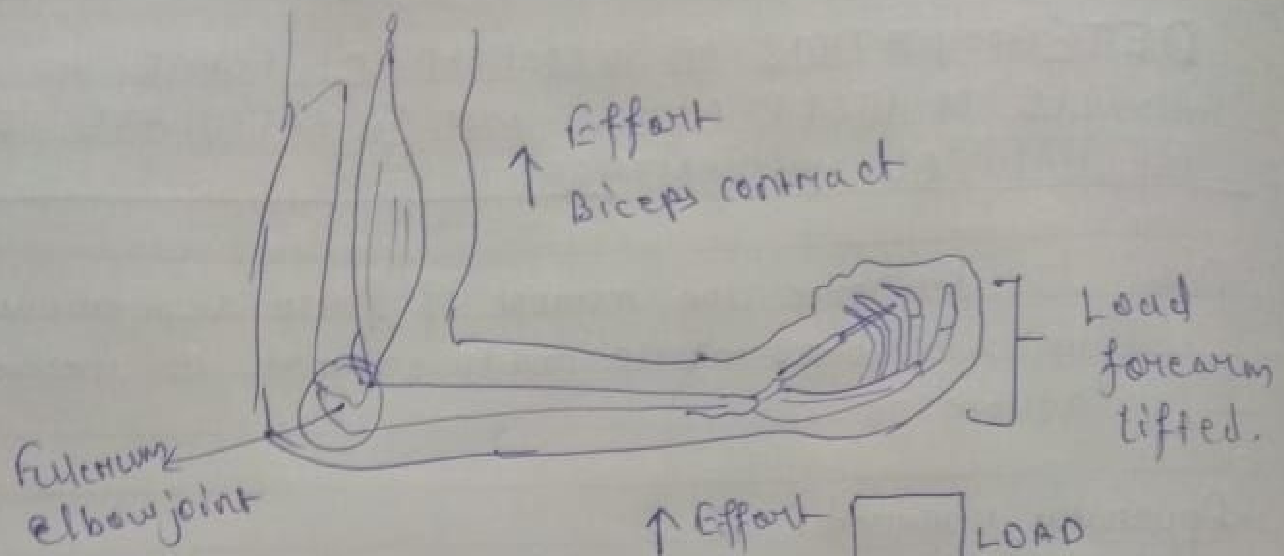
PROCEDURE

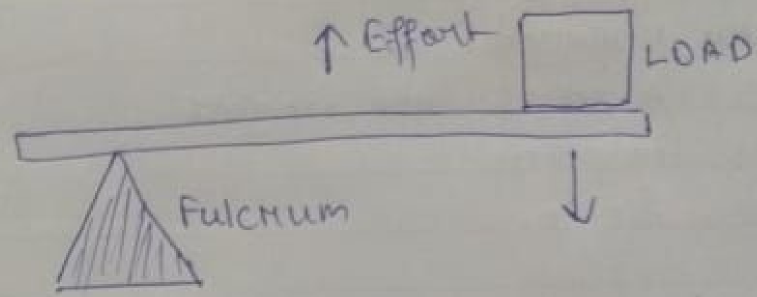
→ Measure the length of the forearm from the bony joint of the elbow to the centre of the palm as to calculate the resistance arm that is needed for calculation.
To find where the joint is, please flex your ~~shoulder~~ elbow and with the help of thumbs and forefingers try to feel the joint and where you feel the bones moving that is the medial epicondyle.

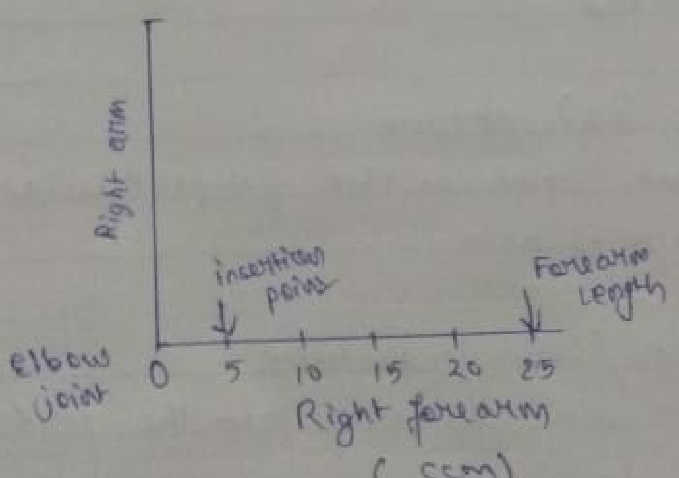
→ Plot this right forearm length (R_A) on x-axis and right arm on the y-axis.

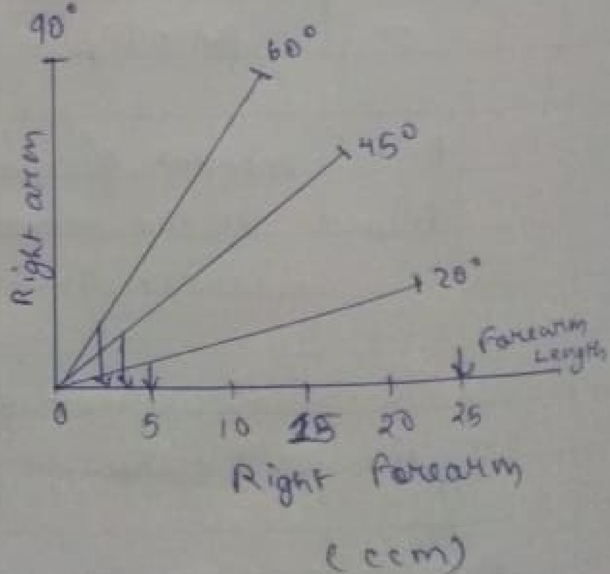
→ Plot the graph of M_A by calculating its distance from the elbow joint to the bicep insertion. on x-axis.
It is 2.54 cm for females and 5 cm for males.

→ Use a protactor to mark the 0°, 30°, 45°, 60° & 90° align the protactor with x-y axis and then draw lines to the following degrees of equal length.


Effort
Biceps contract
Load
forearm
lifted.
Fulcrum
elbow joint


Effort
LOAD
Fulcrum


Right arm
insertion point
Forearm length
Elbow joint
0 5 10 15 20 25
Right forearm
(ccm)


90°
60°
45°
20°
Right arm
Forearm Length
0 5 10 15 20 25
Right forearm
(ccm)

OBSERVATION :-

S.No.	Angle with Horizontal	Max weight at right arm	Max wt at left arm	Moment Arm		Resistance arm		Moment of force.		
				Right (cm)	Left (cm)	Right (RA)	left (RA)	left	Right	avg
1	0°	1	1	5	5	30	30	18.00	18.00	18
2	30°	1	1	4.5	4.5	25	25	16.66	16.66	16.66
3	45°	1	1	3.5	3.5	20	20	17.14	17.14	17.14
4	60°	1	1	3	3	15	12.5	15.00	15.00	13.75
5										

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→ Use a ruler to mark the point of muscle insertion on the line at each angle, the distance from the joint to the remains same through all angles.

→ With the help of a protractor try to draw a perpendicular line from the point of muscle of insertion to the ~~x~~ axis intersecting the axis at right angle. The distance from the joint to the intersection is the moment arm (M_A)

→ Compute all the data at each angle to find the moment of force.

If we want to find the mechanical advantage the.

$$\text{Mechanical Advantage} = \frac{\text{Effort Arm}}{\text{Resistance Arm}}$$

RESULT

The moment of force at various angles of bicep muscle & Mechanical advantage.

Teacher's Signature

Date 26/01/2022

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DETERMINATION OF MUSCLE FATIGUE LIMIT DURING ISOTONIC AND ISOMETRIC MUSCLE CONTRAN

Aim:- The aim of this experiment is to make an estimate of the muscle fatigue limit by two separate methods.

Apparatus Required:-
1. Weights
2. Stopwatch

THEORY:-
- Muscle is a special contractile tissue found in animals. The ability to change the lengths of muscle support a lot of movements like octopus movements and Aplysia peristaltic
- Muscle contraction happen by changing the lengths of muscle according to needs for movement.
- Here actin filaments move over myosin filaments in a sliding manner.
- Ca^{2+} ions form as cross bridges for the filaments to bind to each other.

- Concentric contraction - length of muscle decreases. (flexion)
- Static contraction - length remains constant (flexed fore arm)
- Eccentric Contraction - length of muscle increases (extension)

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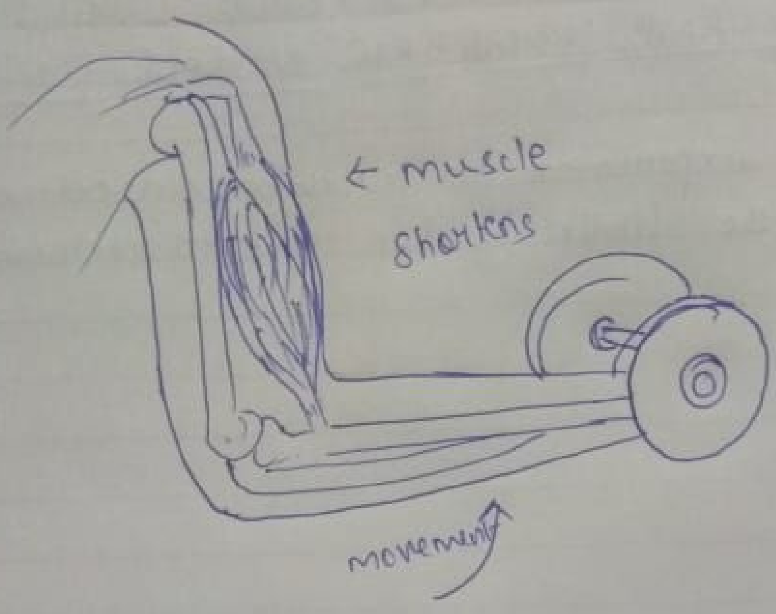
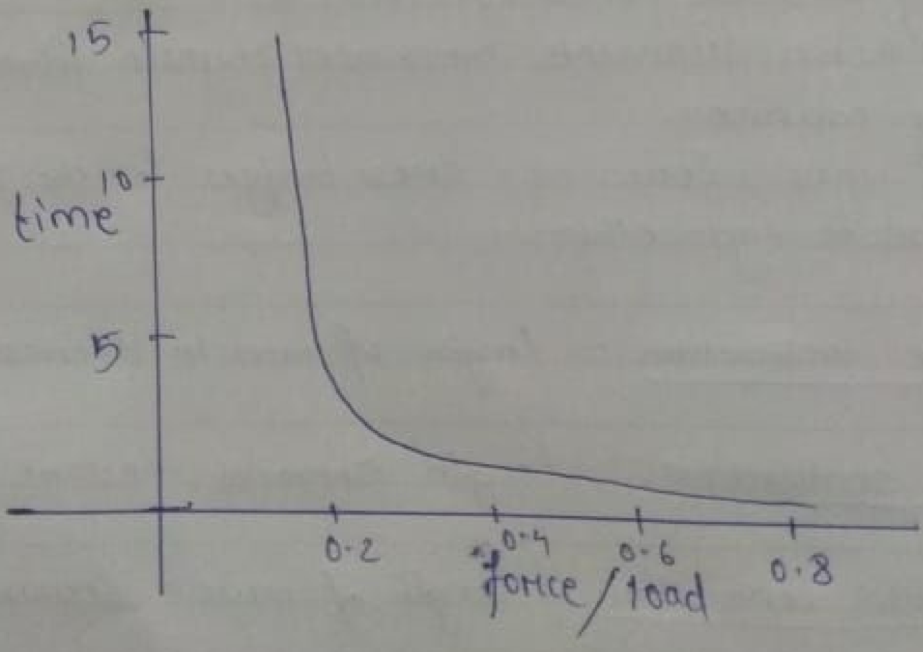
Isotonic



Isometric



Time - Load graph.

★ A muscle can show movement only when shortened. The muscle increases length when it has to control the movement of a part attached to it. It has no motion when the muscle tension overcomes any external force.

★ During the joint's motion in the body, the muscle has to shorten. This is achieved through concentric contraction and muscle is called agonist.

★ Similarly, if it causes eccentric contraction, then it is known as antagonist muscle.

CONTRACTIONS

- Isotonic Contraction - These type of contraction happens only when the tension of the muscle is maintained irrespective of the change in lengths of muscle. This happens when maximal force of contraction exeeds the total load. It can be concentric/eccentric concentration.

- Isometric Contraction -
  Unlike isotonic contraction, here the length remains same but the force is applied. These are found in hands and forearms. This happens when you hold an object in your hand or grip it. The joints and muscles are immovable but genrates anti-gravity force.

OBSERVATION AND CALCULATION

(I) For isotonic contraction

Sl. NO.	Load Applied (kg)	Number of flexion- extension cycles
1	6	10
2	4	19
3	2	62
4	1	140

(II) For Isometric Contraction

Sl. NO	Load Applied (kg)	Time taken to reach muscle fatigue (s)
1	1	35
2	2	26
3	4	9
4	6	2

PROCEDURE

Isotonic

-> Ask a subject to hold a weight with fully extended arm.
-> Then ask him to flex his arm and complete flexion.
-> Repeat this flexion - extension until the hand is unable to lift load or reach muscle fatigue.
-> Vary the load and repeat it.

Isometric

-> Ask the subject to keep arm at 90° to horizontal and hold a weight.
-> Load the arm with the weight & simultaneously start the stop watch.
-> Measure the time interval till which he is able to hold the weight.
-> Give him suitable break and then repeat it.
-> Plot the No of cycles (Time) - Loading data graph.

RESULT

The muscle fatigue limit was evaluated and suited by isotonic and isometric muscle contraction techniques.

DETERMINATION OF FRICTION FACTOR FOR A GIVEN PIPE

Aim:- To observe the head loss that occurs in a pipe due to frictional resistance, hydraulic gradient due to mercury manometer, flow rate and velocity of the water through the apparatus.

APPARATUS REQUIRED

1) Fluid friction Apparatus
2) Water Supply
3) Scale
4) Set up for measuring the actual flow rate.

THEORY

Frictional Resistance to flow.
- The resistance depends on the surface of the conduit on the pipe through its flow.

Frictional resistance in laminar flow - this happens due to viscous resistance.

Friction resistance in turbulent flow - we need two forces for this which are the surface roughness as well as viscosity.

Frictional Resistance Varies.

* degree of roughness of surface.
* the contact of area with the fluid.
* Directly to velocity in laminar flow and square in turbulent flow
* Directly to density of fluid.
* Inversely as viscosity of fluid.

PROCEDURE

1) Connect the U-tube manometer tube to gauge points on the pipeline.
2) Measure the diameter and the length of pipeline between manometric couplings.
3) Open the inlet valve keeping outlet valve closed.
4) Remove the air bubble in manometer tube if any.
5) Open partially the out inlet valve, keeping the common inlet valve fully open.
6) Allow the flow to get stable and take the manometer reading.
7) Measure the discharge by volumetric method.
8) Repeat the steps 5 to 7 for different discharge.

FORMULA

1) Hydraulic Gradient (i)

$$i = \frac{\Delta h \times (13.6 - 1)}{l}$$

Δh = diff manometer

l = Pipe length

Tabulations

SNo	Manometric Deflection 'h' (m)	loss of head due to fric^n $h_f = h \times 12.6$	Rise in tank d	Volume (Area x rise) m^3	Q actual = vol / time (m^3/s)	$f = \frac{h_f \cdot 2gd}{LV^2}$	Average f	
	13×10^{-3}	0.1638	0.05	6.1×10^{-3}	0.648×10^{-3}	0.175		
1	7×10^{-3}	0.0882	0.05	6.1×10^{-3}	0.504×10^{-3}	0.306	0.262	diameter 20 mm
	3×10^{-3}	0.0378	0.05	6.1×10^{-3}	0.2×10^{-3}	0.305		
	27×10^{-3}	0.3402	0.05	6.1×10^{-3}	0.606×10^{-3}	0.034		
2	20×10^{-3}	0.2820	0.05	6.1×10^{-3}	0.503×10^{-3}	0.042	0.035	diameter 30 mm
	13×10^{-3}	0.1638	0.05	6.1×10^{-3}	0.548×10^{-3}	0.033		

2) Flow rate (Q)

$$Q = \frac{V}{T}$$

· Volume filled in the tank
time required to reach same level.

3) Velocity of water (v)

$$v = \frac{Q}{A}$$

4) Frictional factor (f)

$$f = \frac{i(2gd)}{V^2}$$

g - accl^n to gravity
d - inner diameter of pipe.

CALCULATION

for 20mm

$$i = \frac{\Delta h \times (13.6-1)}{L}$$

$$i = 0.42$$

for 30mm

$$i = \frac{\Delta h \times (13.6-1)}{2}$$

$$i = 0.112$$

Aim :- To analyze gait pattern of normal walking using force platform.

Apparatus Required :-

1) Multiaxial force platform (Kistler)
2) Bioware software.

Theory :-

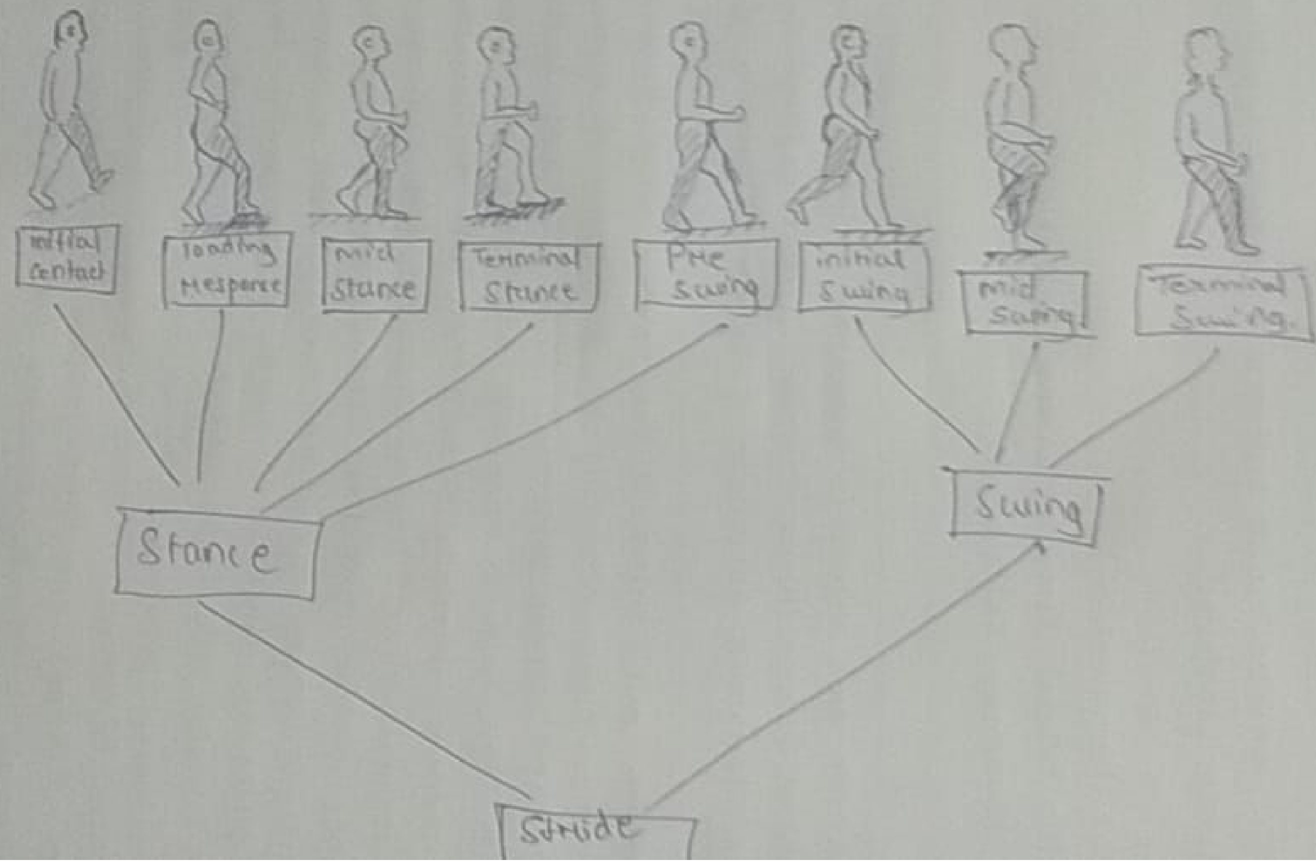
Human gait refers to locomotion achieved throught the movement of human limbs. Human gait is defined as bipedal, biphasic forward propulsion of center of gravity of the human body.

Human gait refers to the various ways in which a human can move, either naturally or as a result of specialized training. There are gender differences in human gait patterns: females tend to walk with smaller steps width and more pelvic movement. Gait analysis generally takes gender into consideration.

The gait cycle begins when one foot contacts the ground. and ends when that foot contacts the ground again. Thus each cycle begins at initial contact with a stance phase. and proceeds through a swing phase untill the cycle. ends with the limbs next initial contact.

Stance phase of gait is divided into four periods, loading response, midstance, terminal stance, and pressuring. Swing phase is divided into three periods: initial swing, mid swing and terminal swing. The beginning and ending of each period and defined by specific events.

Gait Cycle :

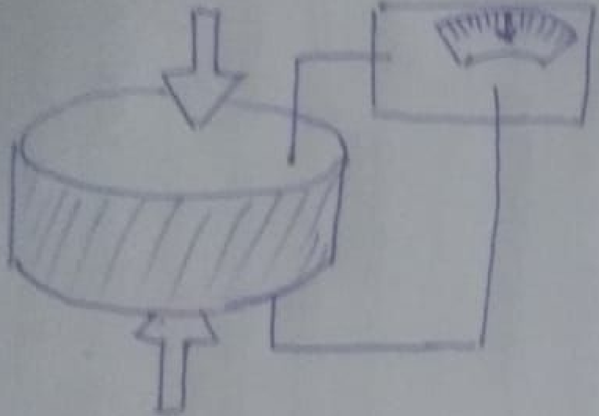

Initial contact
Loading response
Mid Stance
Terminal Stance
Pre swing
initial Swing
Mid Swing
Terminal Swing.
Stance
Swing
Stride

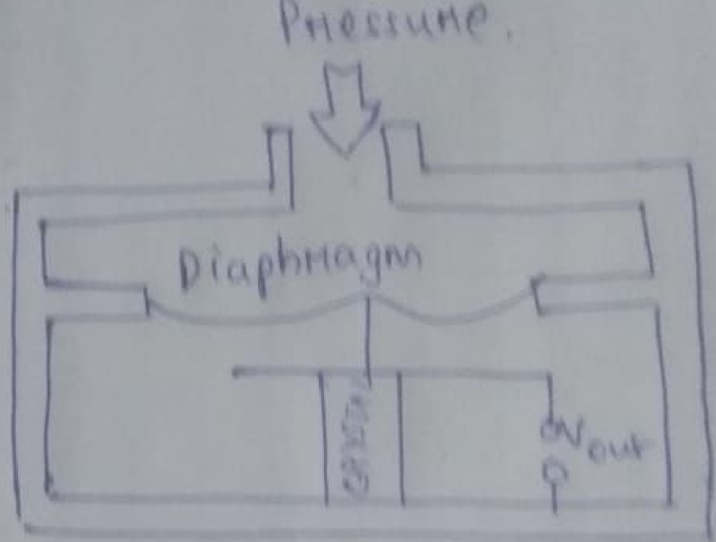
Stance phase:

1.) Heel Strike - It begins with touching the ground.
2) Loading response - begins with initial contact, the instant the foot contacts the ground.
3) Midstance - It is the phase of gait where weight bearing as this limb supports the entire body weight.
4) Terminal stance - defined as the heel rise until the other limb makes contact with floor.
5) Toe off - The limb is rapidly off loaded and the load is transferred to the other limb.

Force Plate:

-> Force platforms are measuring instruments that measure the ground reaction forces generated by a body standing on or moving across them.
-> The Multiaxial force platform is a metal plate consisting of force transducers which measures the force exerted on it.
-> Here the force platform is having force and moment transducer (piezoelectric sensor). It is a device that uses the piezoelectric effect to measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electric charge. The prefix piezo- is Greek for 'press' or 'squeeze'. Piezoelectric materials are materials that have the ability to generate internal electric charge from applied mechanical stress.





(Piezoelectric pressure sensor

PROCEDURE

1) Switch ON the system, 30 minutes prior to the start of the experiment in order to neutralize any kind of drifts occuring on the system.
2) Make sure that the force platform is not reading any kind object load.
3) After this initialize the Bioware software by double clicking on the Bioware soft ware icon on the desktop.
4) Now a page will pop-up containing respective icon toolbar.
5) From the icon toolbar, select acquire trial and measure the body weight of the subject so that the force applied during gate can be computed with proper caliberation.
6) Click on advanced acquisition set-up and select necessary options.
7) Set the time duration according to the experiment to be performed.
8) Similarly standardize the sampling frequency according to the requirement of the experiment.
9) Next start the process by clicking the start button on the pop-up page.
10) Wait untill the system finishes reading the offset voltage
11) Now perform gait activity by clicking enter to the reading offset voltage.
12) Save the gait activities under a filename with an extension .dat.
13) Now study the saved file for ground reaction force, friction, moment and centre of pressure.

14) Other performance parameters like acceleration, velocity etc can also be computed by entering correct instant velocity, acceleration and displacement.

RESULT :

The characteristics graph was obtained and evaluated.

Date 14/02/2022

No. 06 [120BM0014] Page No. 01

OBSTRUCTION FLOW METER : VENTURIMETER

Aim: Find the coefficient of discharge for different rates of flow and plot it. Get idea of how these meters work and theory behind apparatus.

APPARATUS

1) Venturimeter set-up
2) Water supply
3) Manometer
4) Stopwatch
5) Setup for measuring the actual flow rate.

THEORY

This obstruction flow meter is used to measure internal flow. It is calculated by measuring the drop in pressure with inclusion of the obstruction. There are basically 3 type, i.e. Orifice meter, Venturimeter, Pitot tube. Rotatometer is of 2nd category.

Venturimeter is based on the principle of Bernoulli's equation. There the pressure is created by reducing the cross-sectional area of the flow. Therefore, a U-tube is used to measure that. This pressure difference helps in determination rate of flow or discharge and velocity is increased.

Teacher's Signature

Venturimeters are generally made from castings machine to close tolerance to duplicate the performance of standard design, so they are heavy, bulky & expensive. Inside venturimeter, the fluid is accelerated through the converging cone of 15 to 20°. The pressure difference by using differential manometer. The conical downstream gives excellent pressure recovery and overall head loss is low. They are self-cleaning due to smooth internal shape.

The expression for discharge through OFM can be theoretically using continuity & Bernoulli's equations.

$$Q_{th} = \underbrace{A}_{\text{flow area}} \times \underbrace{V}_{\text{flow velocity}}$$

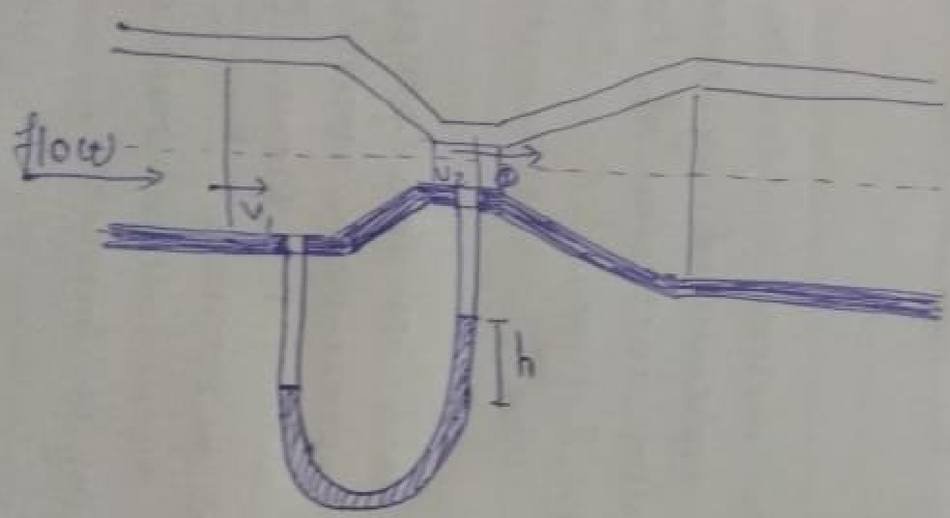
$$d_1 = 0.0224 \text{ m}$$
$$d_2 = 0.0112 \text{ m}$$

$$\beta = d_2/d_1 = 0.5$$

Bernoulli's eqn

$$\frac{P_1}{\rho_w g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho_w g} + \frac{V_2^2}{2g} + Z_2$$

$$V_2 = \sqrt{\frac{2\Delta P}{\rho_w \left\{1 - \left(\frac{A_2}{A_1}\right)^2\right\}}} \qquad \Delta P = P_1 - P_2$$



Venturimeter

Mercury differential monometere to measure ΔP

$$\Delta P = (\rho_{Hg} - \rho_w)$$

ρ_{Hg} = density of manometer fluid. (kg/m³)

ρ_w = density of flowing fluid. (kg/m³)

$$Q_1 = A_1 A_2 \sqrt{\frac{2(\rho_{Hg}/\rho_w - 1)gh}{(A_1^2 - A_2^2)}}$$

Actual discharge $Q_{AC} = \frac{a \times H}{t}$ (m³/s)

a = area of collecting tank (m²)
H = height difference (m)
t = time taken.

$$C_D = \frac{Q_{ac}}{Q_{th}} \quad \text{(or)} \quad C_D = \frac{Q_{as}}{S_2} \sqrt{1-\beta^4} \Big/ \sqrt{2gh}$$

S_2 = area of throat
$\beta = D_1/D_2$

PROCEDURE

1) Check the experimental setup for leaks. Measure the dimension of collection tank. Note the flow meter specifications
2) Open the inlet valve fully and allow the water fully.
3) Make sure the height of mercury colomn in both limbs if there is no discharge.
4) Slightly open the outlet valve of the flow meter and observe the manometer limb.
5) Adjust it to get a steady pressure difference between the limbs of the manometer.
6) Measure the time t to collect H height of water in the collecting tank.
7) Repeat the above procedure for different flow rates by changing the outlet valve opening.
8) Close the inlet to the apparatus after taking the necessary readings.
9) Complete the tabulation and find the average value of C_D.

RESULT & INFERENCE

The average coefficient of discharge of the given obstruction meters are venturimeter C_D =

flow	Manometer Reading			Actual discharge	Time for 4cm rise in collection tank	Initial water level	Final water level	Theoretical discharge Q_{th}	Coefficient discharge C_D
	h_1	h_2	net h (cm)	m^3/s	sec	cm	cm	m^3/s	$\frac{Q_{ac}}{S_2}\sqrt{\frac{1-\beta^2}{2gh}}$
HIGH	7.5	15	0.42	0.61×10^{-3}	20	4.7	14.7	13.4×10^{-4}	1.398
MEDIUM	7.8	12.5	0.592	0.34×10^{-3}	20	5.3	10.9	13.4×10^{-4}	0.983
LOW	5.9	11.9	0.315	0.2×10^{-3}	20	4.8	8.1	13.4×10^{-4}	0.791