

GUJARAT TECHNOLOGICAL UNIVERSITY

BE-4 SEMESTER – OLD PAPER – S22 TO W25 – QUESTION BANK

Subject Name & Code:

Fluid Mechanics and Hydraulics Machines (3141906)

Unit 1: Fluids and Their Properties

Topics: Fluid classifications, viscosity, surface tension, capillarity, vapor pressure, compressibility, Pascal's law, hydrostatic paradox, pressure variation.

Repeated Questions:

1. **Define/Explain viscosity (dynamic/kinematic).**
 - Appeared in: S23 (Q1a-1, 03), S24 (Q1a-1, 03), W25 (Q1a, 03), W23 (Q1a, 03), S25 (Q1a-i, 03)
 2. **Define surface tension and capillarity / capillary rise/fall.**
 - Appeared in: S23 (Q1a-2, 03), S24 (Q1c, 07), W25 (Q1a, 03), W24 (Q1a-iii, 03), W24 (Q1b, 04), S25 (Q1b, 04)
 3. **State and prove Pascal's law.**
 - Appeared in: S23 (Q2b, 04), W25 (Q1b, 04), W22 (Q1b, 04), W23 (Q4b, 04)
 4. **Define vapor pressure and compressibility/bulk modulus.**
 - Appeared in: S23 (Q1a-2,3, 03), S22 (Q1a-iii, 03), W24 (Q1a-iii, 03), S25 (Q1a-iii, 03)
 5. **Explain hydrostatic paradox.**
 - Appeared in: S24 (Q2a, 03), S25 (Q2a, 03)
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Other Important Questions:

1. **Define specific gravity, specific weight, density.**
 - Appeared in: S24 (Q1a-2,3, 03), W25 (Q1a, 03), S22 (Q1a-i, 03), W24 (Q1a-i, 03)
 2. **Explain cohesion and adhesion in fluids.**
 - Appeared in: S23 (Q1b, 04)
 3. **Derive continuity equation for 3D/2D flow.**
 - Appeared in: W25 (Q1c, 07), S24 (Q3b, 04)
 4. **Explain cavitation and its effects.**
 - Appeared in: S25 (Q1b, 04), W24 (Q4a, 03), S23 (Q5a, 03)
 5. **Derive expression for capillary rise/fall.**
 - Appeared in: S24 (Q1c, 07)
 6. **Classify fluids based on viscosity/shear stress relation.**
 - Appeared in: S22 (Q1b, 04)
 7. **Differentiate between absolute, gauge, and vacuum pressure.**
 - Appeared in: S24 (Q2b, 04), W23 (Q3a, 03)
 8. **Determine pressure change in static fluid if we move: horizontally, downward by h, change direction only.**
 - Appeared in: **W24 (Q1c, 07 marks)**
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Unit 2: Static Forces on Surface and Buoyancy

Topics: Resultant force, center of pressure, buoyancy, stability, metacentric height.

Repeated Questions:

1. **Define: Buoyant force, Centre of buoyancy, Metacenter, Metacentric height.**
 - Appeared in: S23 (Q3b, 04 marks), S24 (Q3a, 03 marks), W24 (Q2a, 03 marks)
2. **Explain stability of submerged and floating bodies.**
 - Appeared in: S23 (Q3a, 03 marks), W25 (Q2a, 03 marks)
3. **Show that $BM = \frac{I}{V}$.**
 - Appeared in: S24 (Q3c, 07 marks), W25 (Q2c, 07 marks)
4. **Define metacentric height. List equilibrium conditions for floating body.**
 - Appeared in: S22 (Q2a, 03 marks), S25 (Q2b, 04 marks)

Other Important Questions:

1. **A wooden block 600mm × 600mm × h floats vertically. Find max height for stability (SG=0.6).**
 - Appeared in: S23 (Q3c, 07 marks)
2. **A rectangular block 3m × 1.5m × 1m floats with immersion 0.8m. Find weight, metacentric height.**
 - Appeared in: S24 (Q3b, 04 marks)
3. **A cylinder block (22 kN, D=2m, h=2.5m) floats in seawater (SG=1.025). Show it doesn't float vertically.**
 - Appeared in: S25 (Q2c, 07 marks)
4. **A circular opening 2.5m diameter closed by disc. Find force and torque to keep it vertical (head=3.5m).**
 - Appeared in: W25 (Q2c, 07 marks)
5. **An annular plate (Dext=2m, Dint=1m) immersed vertically with bottom edge 5m below surface. Find force and centre of pressure.**
 - Appeared in: W23 (Q2c, 07 marks)
6. **A rectangular plane 1m×1.5m with 0.5m hole at centre, top edge 1m, bottom 2m below surface. Find force magnitude, direction, location.**
 - Appeared in: S25 (Q2c, 07 marks)
7. **Panel ABC isosceles triangle (base=2m) in slanted tank wall. Find water force and line of action.**
 - Appeared in: W24 (Q2c, 07 marks)
8. **Gate 5m×3m, top edge 2m below water surface. Find hydrostatic force and centre of pressure.**
 - Appeared in: W24 (Q2c, 07 marks)
9. **Isosceles triangular plate (base=5mm, height=5mm) immersed in oil (SG=0.8), base 1m below surface. Find total pressure and centre of pressure.**
 - Appeared in: S22 (Q2c, 07 marks)

Unit 3: Motion of Fluid Particles and Streams

Topics: Types of flow, continuity equation, rotation, vorticity, stream function, velocity potential.

Repeated Questions:

1. **Define: Stream line, Streak line, Path line.**
 - Appeared in: S23 (Q2a, 03 marks), W25 (Q3a, 03 marks)
2. **Define velocity potential and stream function. Relate them.**
 - Appeared in: S22 (Q3a, 03 marks), S25 (Q3a, 03 marks), W24 (Q3a, 03 marks)
3. **Explain rotation and vorticity.**
 - Appeared in: S24 (Q3a, 03 marks), W25 (Q3b, 04 marks)
4. **Derive continuity equation for 3D flow. Reduce for 2D steady incompressible flow.**
 - Appeared in: W25 (Q1c, 07 marks)

Other Important Questions:

1. **Given velocity field $u = 5x, v = -5y$. Check continuity and rotation.**
 - Appeared in: S23 (Q3c, 07 marks)
2. **Given $u = 8 + 4xy + t^2, v = -(xy + 20t), w = 5x + y$. Find velocity and acceleration at (2,1,1) at t=1s.**
 - Appeared in: S24 (Q3c, 07 marks)
3. **Given $u = y^3/3 + 2x - x^2y, v = xy^2 - 2y - x^3/3$. Find stream function.**
 - Appeared in: W25 (Q3b, 04 marks)
4. **Given $V = 2x^3i - 6x^2yj$. Find streamlines.**
 - Appeared in: W22 (Q3a, 03 marks)
5. **Differentiate: Uniform & Non-uniform flow, Steady & Unsteady flow.**
 - Appeared in: S24 (Q2a, 03 marks)
6. **Given $u = Kx, v = Ky, w = 0$. Compute and plot streamlines.**
 - Appeared in: W24 (Q3c, 07 marks)
7. **Given $V = (3y^2 - 3x^2)i + Cxyj + 0k$. Find C for incompressible and irrotational flow.**
 - Appeared in: W24 (Q3c, 07 marks)
8. **Check continuity for $u = x^3 + y^3 - 3xz^2, v = y^3 - 3x^2y, w = x^3 + z^3 - 3yz^2$.**
 - Appeared in: W23 (Q3b, 04 marks)

Unit 4: The Energy Equation and Its Application

Topics: Bernoulli's equation, venturimeter, orifice, notches, weirs, momentum equation.

Repeated Questions:

1. **State and prove Bernoulli's equation. List assumptions and limitations.**
 - Appeared in: W22 (Q1c, 07 marks), W23 (Q1c, 07 marks)
 2. **Explain construction and working of venturimeter. Derive discharge expression.**
 - Appeared in: S25 (Q3c, 07 marks), W23 (Q3c, 07 marks), W25 (Q3c, 07 marks)
 3. **List forces on fluid in motion. Discuss assumptions in Bernoulli's equation.**
 - Appeared in: S23 (Q1c, 04 marks)
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Other Important Questions:

1. **Explain hydraulic gradient line and total energy line.**
 - Appeared in: S22 (Q3b, 04 marks)
 2. **Derive expression for discharge through rectangular notch.**
 - Appeared in: W25 (Q2b, 04 marks)
 3. **Derive expression for centre of pressure for inclined submerged surface.**
 - Appeared in: W22 (Q2c, 07 marks)
 4. **Venturimeter: inlet 200mm, throat 100mm, manometer 180mm Hg, $C_d=0.98$. Find flow rate.**
 - Appeared in: W22 (Q2c, 07 marks)
 5. **Pipe 150mm to 100mm contraction, flow $2 \text{ m}^3/\text{min}$, manometer 80mm. Find head loss and C_c .**
 - Appeared in: S22 (Q3c, 07 marks)
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Unit 5: Dimensional Analysis and Similarities

Topics: Dimensional analysis, Buckingham π -theorem, similarity laws, model testing.

Repeated Questions:

1. **State Buckingham's π -theorem. How to select repeating variables?**
 - Appeared in: S24 (Q4a, 03 marks), W22 (Q3a, 03 marks), W23 (Q2a, 03 marks)
2. **Using π -theorem, show velocity through orifice: $V = \sqrt{2gH}\phi\left[\frac{D}{H}, \frac{\mu}{\rho VH}\right]$.**
 - Appeared in: S24 (Q4c, 07 marks), S25 (Q3c, 07 marks), W22 (Q3c, 07 marks)
3. **Define similitude: Geometric, Kinematic, Dynamic similarity.**
 - Appeared in: S23 (Q4b, 04 marks)

Other Important Questions:

1. **For centrifugal pump, show: $Q = ND^3\phi\left[\frac{gH}{N^2D^2}, \frac{\nu}{ND}\right]$.**
 - Appeared in: S23 (Q4c, 07 marks)
 2. **For disc friction torque in turbulent flow: $T = D^5N^2\rho\phi\left[\frac{\mu}{D^2N\rho}\right]$. Prove using π -theorem.**
 - Appeared in: W25 (Q3c, 07 marks)
 3. **For viscous force on sphere: $F = D^2V^2\rho\phi\left[\frac{\mu}{DV\rho}\right]$.**
 - Appeared in: W23 (Q3c, 07 marks)
 4. **If power P depends on L, D, K, Q, ρ , μ . Find expression using π -theorem.**
 - Appeared in: W24 (Q4c, 07 marks)
 5. **Explain Euler's model law.**
 - Appeared in: S24 (Q4b, 04 marks)
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Unit 6: Viscous and Turbulent Flow

Topics: Reynolds experiment, Hagen–Poiseuille flow, friction factor, Moody diagram, turbulent flow.

Repeated Questions:

1. **Explain Reynolds experiment. Distinguish laminar and turbulent flow.**
 - Appeared in: S23 (Q2c, 07 marks), W24 (Q4b, 04 marks)
 2. **Derive Hagen–Poiseuille formula.**
 - Appeared in: S24 (Q5c, 07 marks), W22 (Q3c, 07 marks), W25 (Q4c, 07 marks)
 3. **Show $f = \frac{64}{Re}$ for viscous flow in pipe.**
 - Appeared in: W22 (Q3b, 04 marks)
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Other Important Questions:

1. **Shaft (D=100mm) in sleeve (L=350mm, clearance=0.08mm) moves at 0.4 m/s under 250N. Find viscosity. If force=750N, find speed.**
 - Appeared in: S23 (Q2c, 07 marks)
 2. **Thin square plate 0.3m×0.3m in oil gap 2.5cm, $\mu=0.2$ Pa·s, velocity=0.2 m/s. Find total force.**
 - Appeared in: S24 (Q2c, 07 marks)
 3. **Disc 120mm diameter rotates in oil film 1.8mm thick at 60 rpm, torque=0.00072 Nm. Find viscosity.**
 - Appeared in: S22 (Q2c, 07 marks)
 4. **Glycerine (SG=1.28, $\mu=8.07$ poise) between plates 1.5cm apart, flow=4.4 m³/hr per m width. Find max velocity, max shear stress, pressure gradient, Re.**
 - Appeared in: S22 (Q3c, 07 marks)
 5. **Prove max velocity in pipe = 2 × avg velocity for viscous flow.**
 - Appeared in: S25 (Q4b, 04 marks), W24 (Q5b, 04 marks)
 6. **Write short note on Saybolt viscometer.**
 - Appeared in: W25 (Q4b, 04 marks)
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Unit 7: Flow Through Pipes

Topics: Major/minor losses, HGL, TEL, pipes in series/parallel, equivalent pipe, water hammer.

Repeated Questions:

1. **What is equivalent pipe?**
 - Appeared in: W22 (Q4a, 03 marks), W23 (Q4a, 03 marks)
 2. **List major and minor losses in pipes.**
 - Appeared in: W24 (Q4a, 03 marks)
 3. **Define water hammer.**
 - Appeared in: S22 (Q3b, 04 marks), W24 (Q4a, 03 marks)
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Other Important Questions:

1. **Pipe $D=250\text{mm}$, $L=60\text{m}$, $V=2.5\text{ m/s}$, Chezy's $C=60$. Find head loss using Chezy's formula.**
 - Appeared in: S24 (Q5a, 03 marks)
 2. **Two pipes $D=60\text{mm}$ & 120mm , $L=200\text{m}$ each in parallel, head= 15m , $f=0.3$. Find flow in each and equivalent pipe diameter.**
 - Appeared in: S25 (Q4c, 07 marks)
 3. **Water supply to hostel: $L=4000\text{m}$, 3000 persons, 180 L/person/day, friction loss= 18m , $f=0.007$, half supply in 8 hrs. Find pipe size.**
 - Appeared in: W23 (Q3c, 07 marks)
 4. **Pipe $D=250\text{mm}$, pressure head diff= 3.5m over 500m , $f=0.04$. Find discharge.**
 - Appeared in: W24 (Q4b, 04 marks)
 5. **Optimum pipe diameter for 100 L/s oil ($\rho=950\text{ kg/m}^3$, $\mu=0.08\text{ Pa}\cdot\text{s}$) for laminar flow over 1 km. Find power required.**
 - Appeared in: W24 (Q4c, 07 marks)
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Unit 8: Impact of Jet and Hydraulic Turbines

Topics: Jet impact on vanes, turbine types, Pelton, Francis, Kaplan, draft tube, governing, cavitation.

Repeated Questions:

1. **Classify hydraulic turbines on various criteria.**
 - Appeared in: S24 (Q4b, 04 marks), S22 (Q4a, 03 marks), W24 (Q5a, 03 marks)
2. **Explain cavitation in hydraulic turbines.**
 - Appeared in: S23 (Q5a, 03 marks), S22 (Q4b, 04 marks), W25 (Q4a, 03 marks)
3. **Compare impulse and reaction turbines.**
 - Appeared in: S23 (Q4b, 04 marks), W22 (Q4b, 04 marks)
4. **Explain governing of Francis turbine.**
 - Appeared in: S22 (Q4c, 07 marks), W24 (Q4c, 07 marks)
5. **Explain draft tube – function and application.**
 - Appeared in: S25 (Q5b, 04 marks), W23 (Q2b, 04 marks), W25 (Q5a, 03 marks), W24 (Q5b, 04 marks)

Other Important Questions:

1. **Jet $D=7\text{cm}$, $V=15\text{ m/s}$, plate moves at 7 m/s , deflection= 165° , smooth plate. Find force, power, efficiency.**
 - Appeared in: S23 (Q5c, 07 marks)
2. **Jet $D=8\text{cm}$, $V=20\text{ m/s}$, plate moves at 12 m/s away from jet. Find force and work done per sec.**
 - Appeared in: S24 (Q4c, 07 marks)
3. **Pelton wheel: Power= 4000 kW , $H=320\text{m}$, speed ratio= 0.45 , jet ratio= 12 , deflection= 165° , $C_v=0.98$, $\eta_o=84\%$, $\eta_g=96\%$, bucket loss= 10% . Find jet dia, tangential force, runner dia, sync speed.**
 - Appeared in: W25 (Q4c, 07 marks)
4. **Pelton wheel: Power= 9560 kW , $H=350\text{m}$, $N=750\text{ rpm}$, $\eta_o=85\%$, jet dia $\leq D/6$, $C_v=0.985$, speed ratio= 0.45 . Find wheel dia, jet dia, number of jets.**
 - Appeared in: W22 (Q4c, 07 marks)
5. **Francis turbine: $H=75\text{m}$, $\eta_h=92\%$, $\eta_o=86\%$, $D_1=1\text{m}$, $D_2=0.5\text{m}$, width= 15cm , guide angle= 18° , vanes radial at inlet. Find power, speed, specific head, vane exit angle.**
 - Appeared in: S22 (Q4c, 07 marks)
6. **Jet $V=12\text{ m/s}$, concave vane, deflection= 120° , vane moves at 5 m/s . Find inlet jet angle for no shock, exit absolute velocity, work done per kg.**
 - Appeared in: W25 (Q5c, 07 marks)
7. **Horizontal jet $V=30\text{ m/s}$, blade moves at 12 m/s , jet leaves at 65° , blade outlet angle= 35° , $D=10\text{cm}$. Find % reduction in relative velocity, force per kg, work per kg.**
 - Appeared in: W24 (Q4c, 07 marks)
8. **Inward flow reaction turbine: reaction= 0.6 , $U_1=10\text{ m/s}$, $V_f=2.2\text{ m/s}$, $D_1=2D_2$, no friction. Find blade angles at entry and exit.**
 - Appeared in: S25 (Q5c, 07 marks)
9. **Derive force exerted by jet on moving curved blade tangentially.**
 - Appeared in: W22 (Q4a, 03 marks)
10. **Explain Kaplan turbine advantages over Francis.**
 - Appeared in: S24 (Q4a, 03 marks), S25 (Q5a, 03 marks)

Unit 9: Centrifugal Pumps

Topics: Pump classification, velocity triangles, efficiencies, NPSH, characteristic curves, priming.

Repeated Questions:

1. **Define priming. Why is it necessary?**
 - Appeared in: S25 (Q4a, 03 marks), W22 (Q5a, 03 marks), W23 (Q5a, 03 marks)
 2. **Define: Manometric, Volumetric, Mechanical, Overall efficiency.**
 - Appeared in: S23 (Q5a, 03 marks), S22 (Q5b, 04 marks)
 3. **List and explain losses in centrifugal pump.**
 - Appeared in: S23 (Q5b, 04 marks), W22 (Q5c, 07 marks)
 4. **Plot and explain characteristic curves of centrifugal pump.**
 - Appeared in: S22 (Q5b, 04 marks), W24 (Q5b, 04 marks)
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Other Important Questions:

1. **Centrifugal pump: $Q=0.118 \text{ m}^3/\text{s}$, $N=1450 \text{ rpm}$, $H=25\text{m}$, $D_2=250\text{mm}$, $b_2=50\text{mm}$, $\eta_{\text{mano}}=75\%$. Find vane angle at outlet.**
 - Appeared in: W22 (Q5c, 07 marks)
 2. **Centrifugal pump: $Q=0.08 \text{ m}^3/\text{s}$, $D_s=20\text{cm}$, suction loss= $12 \times$ velocity head, $H_{\text{mano}}=15\text{m}$, vapour pressure= 80 kPa (vac) . Find max suction height.**
 - Appeared in: S22 (Q5c, 07 marks)
 3. **Derive minimum starting speed for centrifugal pump.**
 - Appeared in: S25 (Q5c, 07 marks)
 4. **Define NPSH.**
 - Appeared in: W24 (Q5a, 03 marks)
 5. **Explain impeller types in centrifugal pump.**
 - Appeared in: W25 (Q4b, 04 marks)
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Unit 10: Hydraulic Machines

Topics: Hydraulic press, accumulator, intensifier, crane, jack, lift, ram, couplings, torque converter, air lift pump.

Repeated Questions:

1. **Explain hydraulic accumulator with sketch and derive capacity equation.**
 - Appeared in: S25 (Q1c, 07 marks), W22 (Q5c, 07 marks), W23 (Q5c, 07 marks), W24 (Q5c, 07 marks), W25 (Q5a, 03 marks)
 2. **Explain hydraulic press with diagram, advantages, disadvantages, applications.**
 - Appeared in: S23 (Q5c, 07 marks)
 3. **Explain fluid coupling and torque converter.**
 - Appeared in: W22 (Q5a, 03 marks), W24 (Q5c, 07 marks)
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Other Important Questions:

1. **Explain air lift pump with sketch and advantages.**
 - Appeared in: W22 (Q5b, 04 marks)
2. **Write note on hydraulic crane.**
 - Appeared in: S24 (Q5c, 07 marks)
3. **Explain working of torque converter with sketch.**
 - Appeared in: W24 (Q5c, 07 marks)
4. **Derive equation for power absorbed in journal bearing.**
 - Appeared in: S25 (Q5b, 04 marks)
