GATE SOLUTIONS
MECHANICAL ENGINEERING

1987 - 2021

IES MASTER PUBLICATION

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IES MASTER PUBLICATION

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E-mail : info.publications@iesmaster.org

Web : iesmasterpublications.com

First Edition : 2016

Second Edition : 2017

Third Edition : 2018

Fourth Edition : 2019

Fifth Edition : 2020

Sixth Edition : 2021

Typeset at : IES Master Publication, New Delhi-110016

PREFACE

The Graduate Aptitude Test in Engineering (GATE) is an All-India examination administered and conducted in eight zones across the country by the GATE Committee comprising of Faculty members from IISc, Bangalore and other seven IITs on behalf of the National Coordinating Board, Department of Education, Ministry of Human Resources Development.

The GATE score/rank is used for admissions to Post Graduate Programmes (ME, M.Tech, MS, direct PhD) in institutes like IIT and IISc, etc. with financial assistance offered by the Ministry of Human Resource Development. PSUs too use the GATE scores for recruiting candidates for various prestigious jobs with attractive remuneration.

The door to GATE exam is through previous year question papers. If you are able to solve question papers in access of 10 years, you are sure to clear the GATE exam, and open new vistas of career and learning.

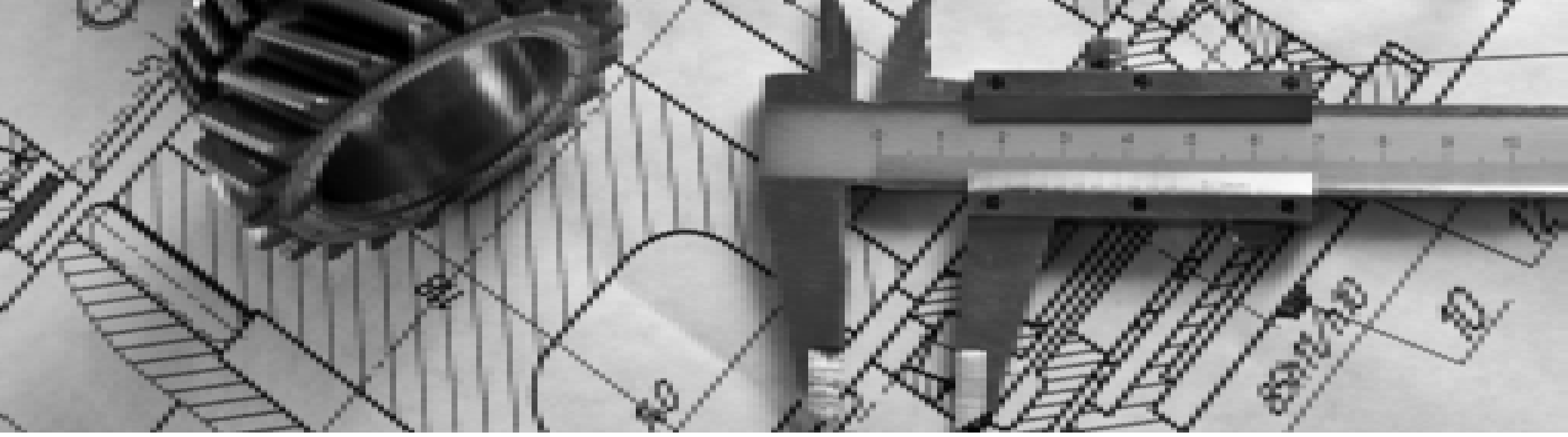
The **Mechanical Engineering GATE 2022** book from IES Master offers detailed topic-wise solutions for the past **35 years** question papers. The emphasis is clearly on the understanding of concepts and building upon a holistic picture. So as you finish a topic, for instance, Planer Mechanism, you will find all the previous years' question papers with detailed explanation under that particular topic.

The approach has been to provide explanation in such a way that just by going through the solutions, students will be able to understand the basic concepts and will apply these concepts in solving other questions that might be asked in future exams.

Every care has been taken to bring an error-free book. However, comments, suggestions, and feedback for improvement in the future editions are most welcome.

IES Master Publication
New Delhi

CONTENT



UNIT-1 FLUID MECHANICS

SYLLABUS

Fluid properties, fluid statics, manometry, buoyancy, forces on submerged bodies, stability of floating bodies, control volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation, dimensional analysis, viscous flow of incompressible fluids, boundary layer; elementary turbulent flow; flow through pipes, head losses in pipes, bends and fittings; basics of compressible fluid flow.

Turbomachinery: impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines.

CONTENTS

1 FLUID PROPERTIES

1– Mark

1. A pressure measurement device fitted on the surface of a submarine, located at a depth H below the surface of an ocean, reads an absolute pressure of 4.2 MPa. The density of sea water is 1050 kg/m^3, the atmospheric pressure is 101 kPa, and the acceleration due to gravity is 9.8 m/s^2. The depth H is _____ m (round off to the nearest integer).

[GATE 2021 SET I]

2. Consider fully developed, steady state incompressible laminar flow of a viscous fluid between two large parallel horizontal plates. The bottom plate is fixed and the top plate moves with a constant velocity of U = 4 m/s. Separation between the plates is 5 mm. There is no pressure gradient in the direction of flow. The density of fluid is 800 kg/m^3, and the kinematic viscosity is 1.25×10^{-4} m^2/s. The average shear stress in the fluid is _____ Pa (round off to the nearest integer).

[GATE 2021 SET I]

3. The difference in pressure (in N/m^2) across an air bubble of diameter 0.001 m immersed in water (surface tension = 0.072 N/m) is _______

[GATE 2014]

4. For a Newtonian fluid

(a) Shear stress is proportional to shear strain

(b) Rate of shear stress is proportional to shear strain

(c) Shear stress is proportional to rate of shear strain

(d) Rate of shear stress is proportional to rate of shear strain

[GATE 2006]

5. A static fluid can have

(a) non-zero normal and shear stress

(b) negative normal stress and zero shear stress

(c) positive normal stress and zero shear stress

(d) zero normal stress and non-zero shear stress

[GATE 2001]

6. The SI unit of kinematic viscosity (ν) is

(a) m^2/sec (b) kg/(m-sec)

(c) m/sec^2 (d) m^3/sec^2

[GATE 2001]

7. Kinematic viscosity of air at 20°C is given to be 1.6×10^{-5} m^2/s. Its kinematic viscosity at 70°C will be vary approximately

(a) 2.2×10^{-5} m^2/s (b) 1.6×10^{-5} m^2/s

(c) 1.2×10^{-5} m^2/s (d) 3.2×10^{-5} m^2/s

[GATE 1999]

8. If ‘p’ is the gauge pressure within a spherical droplet, the gauge pressure within a bubble of the same fluid and of same size will be

(a) $\frac{p}{4}$ (b) $\frac{p}{2}$

(c) p (d) 2p

[GATE 1999]

9. Match 4 correct pairs between List-I and List-II.

List-I

(A) Steam nozzle (B) Compressible flow

(C) Surface tension (D) Heat conduction

List-II

(1) Mach Number

(2) Reaction Turbine

(3) Biot Number

(4) Nusselt Number

(5) Super saturation

(6) Weber Number

[GATE 1997]

10. The dimension of surface tension is

(a) ML^{-1} (b) L^2T^{-1}

(c) $ML^{-1}T^2$ (d) MT^{-2}

[GATE 1996]

11. A fluid is said to be Newtonian when the shear stress is

(a) directly proportional to the velocity gradient

(b) inversely proportional to the velocity gradient

(c) independent of the velocity gradient

(d) none of the above

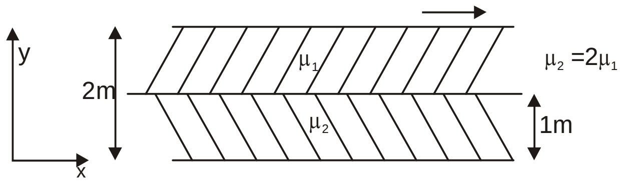
[GATE 1995]

2– Marks

1. Two immiscible, incompressible, viscous fluids having same densities but different viscosities are contained between two infinite horizontal parallel plates, 2 m apart as shown below. The bottom plate is fixed and the upper plate moves to the right with a constant velocity of 3 m/s. With the assumptions of Newtonian fluid, steady, and fully developed laminar flow with zero pressure gradient in all directions, the momentum equations simplify to

$$\frac{d^2u}{dy^2} = 0$$

If the dynamic viscosity of the lower fluid, μ_2 is twice that of the upper fluid, μ_1, then the velocity at the interface (round off to two decimal places) is ____ m/s.



[GATE 2019 SET I]

2. Consider fluid flow between two infinite horizontal plates which are parallel (the gap between them being 50 mm). The top plate is sliding parallel to the stationary bottom plate at a speed of 3 m/s. The flow between the plates is solely due to the motion of the top plate. The force per unit area (magnitude) required to maintain the bottom plate stationary is ____N/m^2.

Viscosity of the fluid $\mu = 0.44$ kg/m-s and density ρ = 888 kg/m^3.

[GATE 2016]

ANSWER KEY

:: 1 MARK ::			:: 2 MARKS ::
1. (398)	4. (c)	8. (d)	1. (1)
2. (80)	5. (b)	9. (a–5, b–1, c–6, d–3)	2. (26.4)
3. (288 N/m²)	6. (a)	10. (d)	
	7. (a)	11. (a)	

EXPLANATIONS

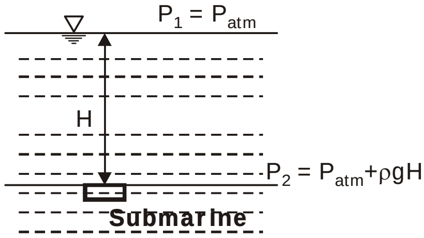
1– Mark

Sol–1: (397 to 399)

Given: Atmospheric pressure, P_{atm} = 101 kPa

Sea water density, $\delta_{\text{sea water}}$ = 1050 kg/m^3

Pressure on submarine, P_2 = 4.2 MPa



$$P_2 = P_{atm} + \rho gh$$

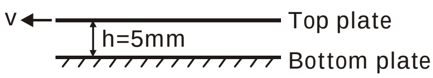
$$4.2 \times 1000 = 101 + \frac{1050 \times 9.8 \times H}{1000}$$

$$H = \frac{4099}{1.05 \times 9.8}$$

$$= 398.35 \text{ m}$$

Sol–2: (79 to 81)

Given: Fully developed steady laminar flow between two parallel plates,

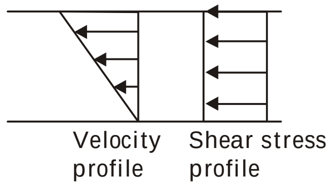


Fluid density, δ = 800 m^3/kg

Distance between plate, h = 5 mm

Kinematic viscosity, $\nu = 1.25 \times 10^{-4}$ m^2/s

As plate separation distance is very less. Hence, we can assume a linear velocity profile between plates.



$$\tau = \mu\left(\frac{\partial u}{\partial y}\right) = \frac{\mu v}{h}$$

$$\tau = \frac{\rho \nu v}{h}$$

$$= \frac{800 \times 1.25 \times 10^{-4} \times 4}{5 \times 10^{-3}}$$

$$= 80 \text{ N/m}^2$$

Sol–3: (288)

The pressure difference across an air bubble in water,

$$\Delta P = \frac{4\sigma}{d} = \frac{4 \times 0.072}{0.001}$$

$$= 288 \text{ N/m}^2$$

$$\boxed{\Delta p = 288 \text{ N/m}^2}$$

Sol–4: (c)

A fluid is said to be a Newtonian fluid, if the shear stress is directly proportional to rate of angular deformation or rate of shear strain or velocity gradient,

Sol–5: (b)

A static fluid can never have shear stress and has negative normal stress.

Sol–6: (a)

$$\nu = \frac{\mu}{\rho}$$