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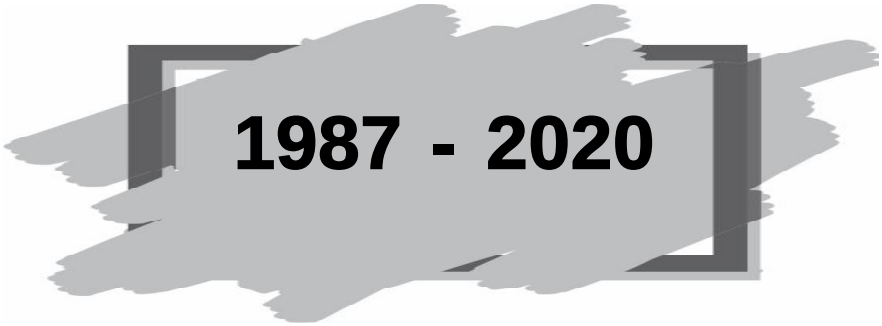
MECHANICAL ENGINEERING



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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 2021** book from IES Master offers detailed topic-wise solutions for the past 34 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.

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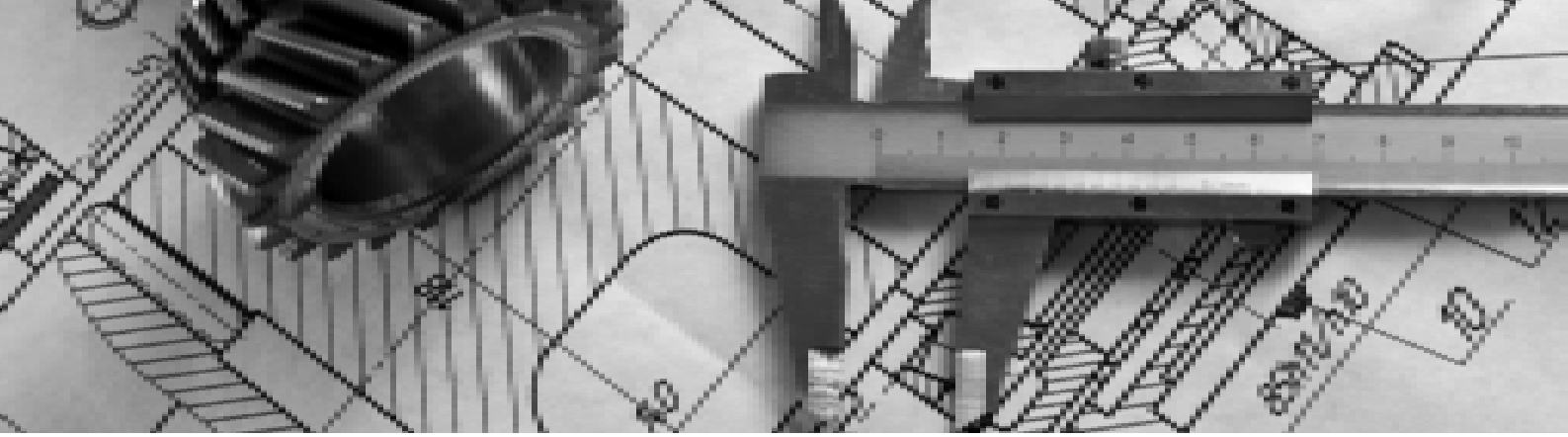
CONTENT



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.

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

CONTENTS

1 FLUID PROPERTIES

1– Mark

1. 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]

2. 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]

3. 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]

4. 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]

5. 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]

6. 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]

7. 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]

8. The dimension of surface tension is

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

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

[GATE 1996]

9. 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]

ANSWER KEY

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

EXPLANATIONS

1– Mark

Sol–1: (288)

The pressure difference across an air bubble in water,

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

$$= 288\ N/m^2$$

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

Sol–2: (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–3: (b)

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

Sol–4: (a)

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

$$\text{unit of } \nu = \frac{N\text{-}s/m^2}{kg/m^3} = \frac{kg/m\text{-}s}{kg/m^3}$$

$$\boxed{\nu = m^2/sec}$$

Sol–5: (a)

$$\nu_{20^\circ C} = 1.6 \times 10^{-5}\ m^2/s$$

Dynamic & kinematic viscosity of air increases with increase in temperature. Kinematic viscosity of air at 70°C is about $2.2 \times 10^{-5}\ m^2/s$.

Sol–6: (d)

For spherical droplet :

$$\sigma \times \pi d = p \times \frac{\pi}{4} d^2$$

$$\sigma = \frac{pd}{4} \quad \text{.....(1)}$$

For spherical bubble :

$$\sigma \times \pi d \times 2 = p_b \times \frac{\pi}{4} d^2$$

$$\sigma = \frac{p_b d}{8} \quad \text{.....(2)}$$

Equating the surface tensions in equation (1) and (2)

$$\frac{pd}{4} = \frac{p_b d}{8}$$

$$\boxed{p_b = 2p}$$

Sol–7: $\boxed{A-5;\ B-1;\ C-6;\ D-3}$

Mach Number is related to compressible flow. Weber number is related to surface tension. Supersaturation of steam takes place in steam nozzle due to delay in condensation. Biot number is relevant to heat conduction.

Sol–8: (d)

Surface Tension, σ

$$\sigma \times L = \text{Force}$$

$$\sigma = \frac{\text{Force}}{L} = \frac{MLT^{-2}}{L}$$

$$\boxed{\sigma = MT^{-2}}$$