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MECHANICAL ENGINEERING

GATE

2019

32 YEARS SOLUTION

MECHANICAL ENGINEERING GATE-2019

32 YEARS SOLUTION

GATE SOLUTIONS

MECHANICAL ENGINEERING

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PREFACE

It is an immense pleasure to present topic wise previous years solved paper of GATE Exam. This booklet has come out after long observation and detailed interaction with the students preparing for GATE exam and includes detailed explanation to all questions. 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.

GATE exam now a days has become more important because it not only opens the door for higher education in institutes like IIT, IISC, NIT's but also many of the PSUs have started inducting students on the basis of GATE score. In PSU's, which are not inducting through GATE route, the questions in their exams are asked from GATE previous year papers. Thus, availability of authentic solutions to the students is the need of the day. Towards this end this booklet becomes indispensable.

I am thankful to IES master team without whose support, I don't think, this book could have been flawlessly produced.

Every care has been taken to bring an error free book. However comments for future improvement are most welcome.

Mr. Kanchan Kumar Thakur
Director Ex-IES

CONTENTS

Fluid Mechanics

Unit 1

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

Contents

Chapter 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) $10^{-5} \times m^2/s$

[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]

2 – Marks

1. 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 ::

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

:: 2 MARKS ::

1. (26.4)

SOLUTION...

1 – Mark

Sol–1:

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–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: **(c)**

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

Sol–4: **(a)**

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

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

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

Sol–5: **(a)**

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

Dynamic & kinematic viscosity of air increases with increase in temperature. Kinematic viscosity of air at 70°C is about 2.2×10^{-5} m²/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: $\boxed{\textbf{A}-\textbf{5; B}-\textbf{1; C}-\textbf{6; D}-\textbf{3}}$

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

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

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

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

Sol–9: **(a)**

For a Newtonian Fluid :

Shear stress, $\boxed{\tau = \mu\left(\frac{du}{dy}\right)}$

where, $\frac{du}{dy}$ is velocity gradient & μ – dynamic viscosity of fluid.

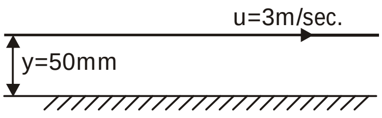
2 – Marks

Sol–1: (26.4)

Fluid viscosity

$$\mu = 0.44 \text{ kg/m-sec}$$

$$= 0.44 \text{ N-sec/m}^2$$



From Newton's law of viscosity,

$$F = \mu A \cdot \frac{du}{dy}$$

$$F/A = \mu \cdot \frac{du}{dy}$$

(Assuming linear velocity profile of fluid flow in the gap)

$$= 0.44 \times \frac{3-0}{5 \times 10^{-2}} = 26.4 \text{ N/m}^2$$

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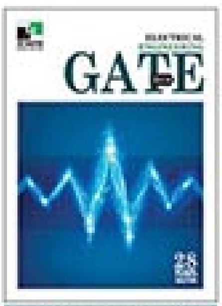

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