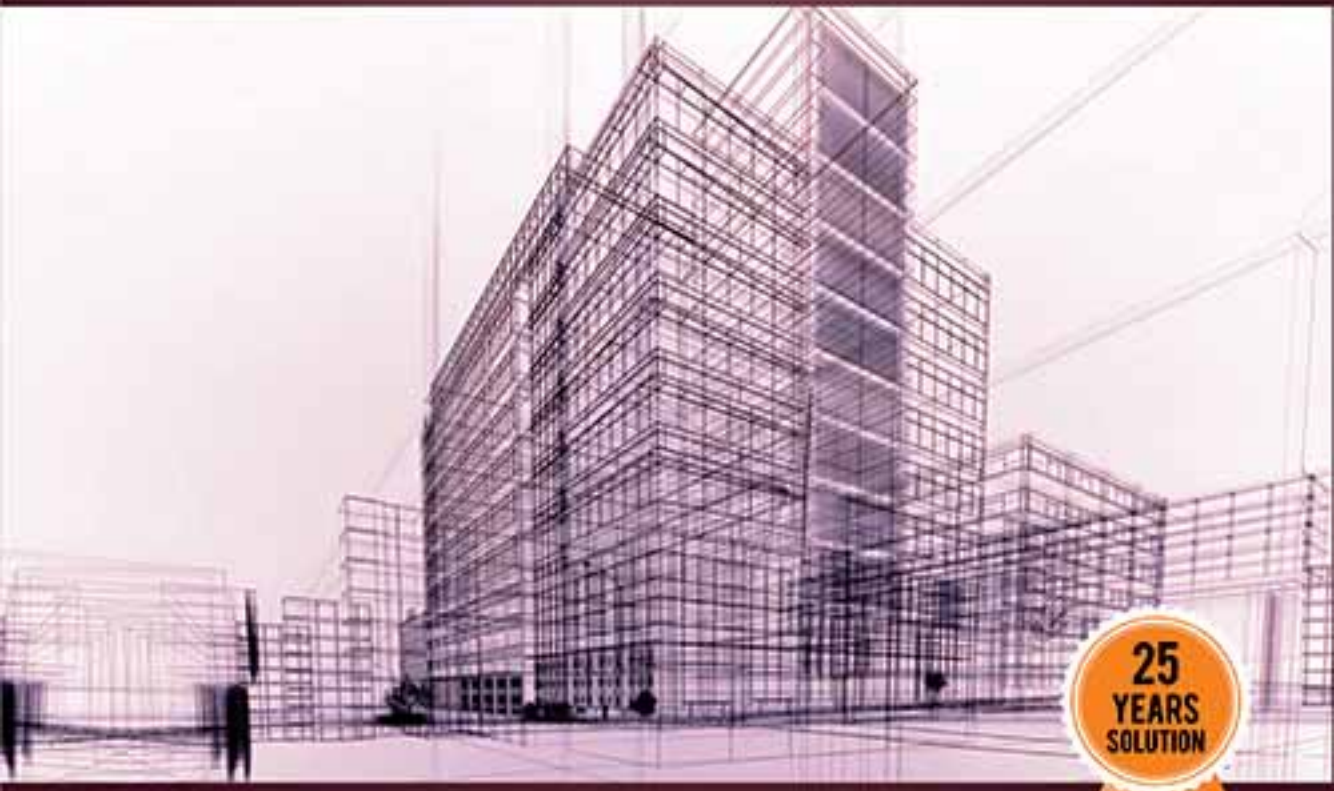
ESE 2020

PRELIMINARY EXAMINATION

IES MASTER PUBLICATION

CIVIL ENGINEERING

ESE TOPICWISE OBJECTIVE SOLVED PAPER-II



25 YEARS SOLUTION

- Detailed Solution
- Topicwise Description
- Fully Revised & Updated

UPSC Engineering Service Examination 2020

CIVIL ENGINEERING

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PAPER-II

1995-2019

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PREFACE

Engineering Services Examination is the gateway to an immensely satisfying job in the engineering sector of India that offers multi-faceted exposure. The exposure to challenges and opportunities of leading the diverse field of engineering has been the main reason behind engineering students opting for Engineering Services as compared to other career options. To facilitate selection into these services, availability of arithmetic solution to previous years' paper is the need of the day.

It is an immense pleasure to present previous years' topic-wise objective solved papers of Engineering Services Examination (ESE). This book is an outcome of regular and detailed interaction with the students preparing for ESE every year. It includes solutions along with detailed explanation to all questions. The prime objective of bringing out this book is to provide explanation to each question in such a manner that just by going through the solutions, students will be able to understand the basic concepts and have the capability to apply these concepts in solving other questions that might be asked in future exams. Towards the end, this book becomes indispensable for every ESE aspiring candidate.

IES Master Publication
New Delhi

CONTENT

UNIT-1 FLUID MECHANICS

SYLLABUS

(A) FLUID MECHANICS, OPEN CHANNEL FLOW, PIPE FLOW

Fluid Properties, Viscosity, Cavitation, Pressure, Thrust, Buoyancy: Flow Kinematics; Integration of flow equations, Flow measurement: Relative motion; Moment of momentum, Boundary layer and Control. Drag, Lift; dimensional Analysis. Modelling, Flow development and losses in pipe flows. Measurements; Siphons, Surges and Water hammer; Delivery of Power Pipe networks. Flow oscillations- Momentum and Energy principles in Open channel flow, Flow controls, Hydraulic jump. Flow sections and properties, Normal flow. Gradually varied flow; Surges.

(B) HYDRAULIC MACHINES AND HYDROPOWER

Centrifugal pumps, types, performance parameters, scaling, pumps in parallel; Reciprocating pumps, air vessels, performance parameters; Hydraulic ram; Hydraulic turbines, types, performance parameters, controls, choice; Power house, classification and layout, storage, poundage, control of supply.

CONTENTS

1 FLUID PROPERTIES

IES-1997

1. Which one of the following pressure units represents the LEAST pressure?

(a) millibar (b) mm of mercury

(c) N/mm^2 (d) kgf/cm^2

IES-1998

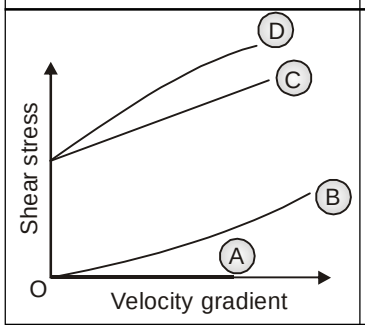
2. The surface tension of water at 20°C is 75×10^{-3} N/m. The difference in the water surface within and outside an open-ended capillary tube of 1mm internal bore, inserted at the water surface would nearly be

(a) 5 mm (b) 10 mm

(c) 15 mm (d) 20 mm

IES-1999

3. Match **List-I (curves labelled A, B, C and D in figure)** with **List-II (types of fluid)** and select the correct answer:

List-I	List-II
	**1.** Ideal plastic **2.** Ideal **3.** Non-Newtonian **4.** Pseudoplastic **5.** Thixotropic

Code:

	A	B	C	D
(a)	2	3	1	5
(b)	3	2	1	5
(c)	4	2	5	1
(d)	2	3	5	1

4. Consider the following statements

In order to have cavitation

1. Local velocity is increased so that the local pressure is decreased below vapour pressure.
2. Elevation is kept so high that the local pressure is reduced below vapour pressure.
3. General ambient pressure is increased to a very high magnitude.
4. Water hammer must occur in the system.

Which of these statements are correct?

(a) 2 and 3 (b) 3 and 4

(c) 1 and 2 (d) 1 and 4

IES-2001

5. Match **List-I** with **List-II** and select the correct answer:

List-I	List-II
A. Concentrated sugar solution	**1.** Dilatant fluid
B. Sewage sludge	**2.** Bingham plastic fluid
C. Blood	**3.** Pseudoplastic fluid
D. Air	**4.** Newtonian fluid

Code:

	A	B	C	D
(a)	1	2	3	4
(b)	1	2	4	3
(c)	2	1	3	4
(d)	2	1	4	3

IES-2002

6. Match **List-I (Definitions)** with **List-II (Properties)** and select the correct answer

List-I	List-II
A. Newtonian fluid	**1.** Frictionless and incompressible
B. Ideal fluid	**2.** Viscosity invariant with shear stress
C. Thixotropic fluid	**3.** Viscosity decreases at higher shear stress
D. Rheological fluid	**4.** Viscosity increases at higher shear stress

Code:

	A	B	C	D
(a)	2	4	1	3
(b)	3	1	4	2
(c)	2	1	4	3
(d)	3	4	1	2

IES-2003

7. Which one of the following statements is correct?

(a) Dynamic viscosity of water is nearly 50 times that of air

(b) Kinematic viscosity of water is 30 times that of air

(c) Water in soil is able to rise a considerable distance above the groundwater table due to viscosity

(d) Vapour pressure of a liquid is inversely proportional to the temperature

8. Which of the following fluids can be classified as non-Newtonian?

1. Kerosene oil
2. Diesel oil
3. Human Blood
4. Toothpaste
5. Water

Select the correct answer using the codes given below :

(a) 1 and 2 (b) 3 and 4

(c) 2 and 5 (d) 1 and 5

IES-2004

9. **Assertion (A) :** At the standard temperature, the kinematic viscosity of air is greater than that of water at same temperature

Reason (R) : The dynamic viscosity of air at standard temperature is lower than that of water at the same temperature.

IES-2006

10. A flat plate of 0.15 m^2 is pulled at 20 cm/s relative to another plate, fixed at a distance of 0.02 cm from it with a fluid having $\mu = 0.0014\ Ns/m^2$ separating them. What is the power required to maintain the motion?

(a) 0.014 W (b) 0.021 W

(c) 0.035 W (d) 0.042 W

IES-2007

11. Which one of the following expresses the height of rise or fall of a liquid in a' capillary tube?

(a) $\frac{4wd}{\sigma \cos \alpha}$ (b) $\frac{\sigma \cos \alpha}{4\ w\alpha}$

(c) $\frac{4\sigma \cos \alpha}{wd}$ (d) $\frac{wd}{4\sigma \cos \alpha}$

w = Specific weight of the liquid

a = Angle of contact of the liquid surface

s = Surface tension

IES-2009

12. Consider the following statements :

Cavitation generally results from a combination of several influences

1. by reduction of pressure intensity below a limiting value
2. by increase in either elevation or the velocity of flow
3. by reduction of pressure load in the system
4. by decrease in the velocity of flow

Which of the above statements are correct?

(a) 1, 2 and 3 (b) 1 and 2 only

(c) 2 and 3 only (d) 3 and 4

IES-2010

13. Match **List-I (Curve identification in figure)** with **List-II (Nature of fluid)** and select the correct answer using the codes given below the lists:'

ANSWER KEY

1. (a)	**8.** (b)	**15.** (b)	**22.** (b)	**29.** (c)
2. (c)	**9.** (b)	**16.** (d)	**23.** (c)	**30.** (a)
3. (a)	**10.** (d)	**17.** (c)	**24.** (c)	**31.** (b)
4. (c)	**11.** (c)	**18.** (d)	**25.** (c)	
5. (a)	**12.** (b)	**19.** (b)	**26.** (a)	
6. (c)	**13.** (a)	**20.** (d)	**27.** (c)	
7. (a)	**14.** (a)	**21.** (c)	**28.** (c)	

EXPLANATIONS

1. (a) 1 millibar $= 10^{-3} \times 10^5$ N/m^2 = 100 N/m^2

1 mm of Hg $= 10^{-3}$ m of Hg

$= 10^{-3} \times 13.6$ m of water

$= 10^{-3} \times 13.6 \times 9810$

$= 133.41$ N/m^2

1 N/mm^2 $= 10^6$ N/m^2

$$1\text{Kgf/cm}^2 = \frac{9.81\text{N}}{10^{-4}\text{m}^2} = 98.1 \times 10^3 \text{ N/m}^2$$

2. (c) For equilibrium

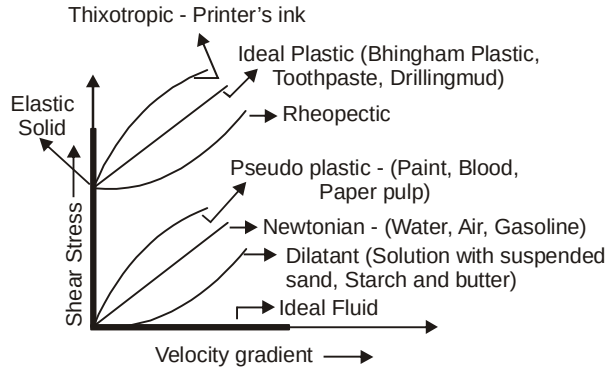
$$2\pi r\sigma = \pi r^2 h\rho g$$

$$\Rightarrow \quad h = \left(\frac{2\sigma}{r\rho g}\right) = \frac{2 \times 75 \times 10^{-3}}{(10^{-3} \times 10^3 \times 10)} = 15\times10^{-3} \text{ m}$$

h = 15 mm

3. (a) Curve between shear stress (τ) and velocity gradient (du/dy) is:

$$\tau \text{ and } \frac{\partial u}{dy}$$



4. (c) Cavitation is the formation of vapour bubbles of a flowing liquid in a region where pressure falls below the vapour pressure and sudden collapsing of these vapour bubbles in a region of high pressure. Pressure may fall below vapour pressure due to increase in local velocity, increase in elevation etc.

5. (a)

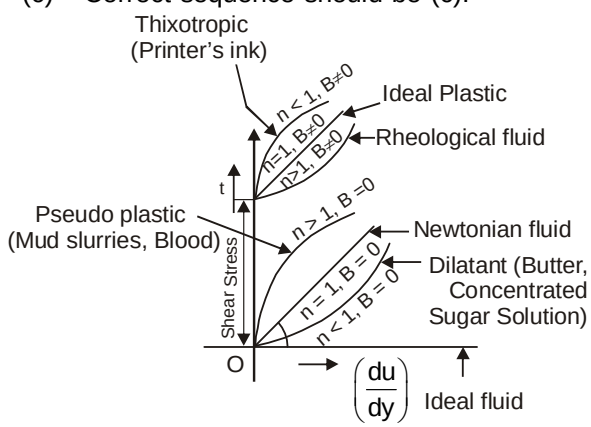
(i) **Dilatant Fluid:** Shear thickening fluid *e.g.*, Solution with suspended sand, conc. sugar solution.

(ii) **Pseudo Plastic Fluid:** Shear thinning fluid. Apparent viscosity decrease with increase in velocity gradient *e.g.*, blood, milk

(iii) **Bingham Plastic/Ideal Plastic:** It has some initial strength beyond which deformation starts *e.g.*, Toothpaste, Sewage sludge.

(iv) **Newtonian fluid:** Water, air, gasoline and oil.

6. (c) Correct sequence should be (c).



General equation for fluid shear stress

$$\tau = A\left(\frac{du}{dy}\right)^n + B$$

$$\therefore \quad \tau = \left\{A\left(\frac{du}{dy}\right)^{n-1}\right\}\left(\frac{du}{dy}\right) + B$$

where, Apparent viscosity = $A\left(\frac{du}{dy}\right)^{n-1}$

Now when B = 0,

n = 1 ... Newtonian fluid, viscosity invariant of shear stress.

n > 1 ... Shear thickening fluid i.e., apparent viscosity increases with increase in deformation

n < 1 ... Shear thinning i.e., apparent viscosity decreases with increase in shear stress (Psedo plastic)

Now when B ≠ 0,

n = 1 ... Ideal Bingham fluid (tooth paste)

n > 1 ... Rheological fluid *i.e.*, apparent viscosity increases with increase in shear stress

n < 1 ... Thixotropic *i.e.*, apparent viscosity decreases with increase in shear stress.

7. (a) Dynamic viscosity of water is nearly 50 times that of air.

$$\mu_w = 8.90 \times 10^{-4} \text{ Pa.sec}$$

$$\mu_{air} = 1.81 \times 10^{-5} \text{ Pa.sec}$$

$$\frac{\mu_w}{\mu_{air}} = \left(\frac{8.90\times10^{-4}}{1.81\times10^{-5}}\right) = 49.17 \simeq 50$$

- Water in soil is able to rise a considerable distance above ground water table due to capillary action.
- Vapour pressure increases with the increase in temperature

8. (b) Example of Newtonian fluid → Kerosene oil, Air, Water, Diesel oil.

Example of Non-Newtonian fluid → Human blood, Tooth paste etc.

9. (b) Dynamic viscosity of water is approximately 50 times that of air, but density water is around 850 times more than air so kinematic viscosity of air is more than that of water and defined as

$$\text{Kinematic viscosity} = \frac{\text{Dynamic viscosity}}{\text{density}}$$

Hence, both the statements are correct but R is not the correct explanation of A.

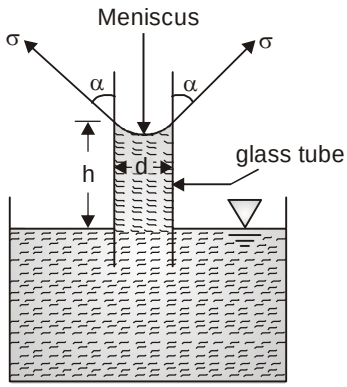
10. (d) Power = force × velocity

$$= \mu A\left(\frac{du}{dy}\right) \times V$$

$$= 0.0014 \times 0.15 \times \left(\frac{20}{0.02}\right) \times 20 \times 10^{-2}$$

$$= 0.042 \text{ W}$$

11. (c)



Surface tension force in upward direction

$$= \sigma\pi d \cos\alpha \quad \text{... (i)}$$

∴ Weight of the liquid in the downward direction

$$= \left(\frac{\pi}{4}d^2h\right)w \quad \text{... (ii)}$$

Equating (i) and (ii)

$$\Rightarrow \quad \sigma\pi d \cos\theta = \left(\frac{\pi}{4}d^2h\right)w$$

$$h = \left(\frac{4\sigma\cos\alpha}{wd}\right) \quad \text{... (iii)}$$

12. (b)

- Cavitation is the formation of vapour bubble in a flowing liquid in the region where the pressure falls below the vapour pressure and sudden collapsing of these vapour bubbles in the high pressure region.
- We know Bernoulli's equation

$$\frac{P}{\gamma} + \frac{v^2}{2g} + z = \text{constant}$$

If we increase either elevation or velocity of flow, it would result in decrease in pressure head so chances of cavitation are more.

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