DSSSB AE/JE 2026

# COMPLETE BASICS OF MECHANICAL ENGINEERING NOTES

Complete Theory • Detailed Hinglish Explanation • Step-by-Step Derivations
Solved Examples • Engineering Applications • Practice Questions

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How to use this book: Read Complete Theory, reinforce it with the Hinglish Explanation, review every formula and derivation row, then attempt all twenty questions without viewing the solutions. Questions are original DSSSB-style practice, not claimed verbatim previous-year questions.



## Mechanical Engineering Constants and Conventions

1. $g = 9.81\ m/s^2$
2. $R_{air} = 287\ J\ kg^{-1}\ K^{-1}$
3. $1\ kPa = 1\ kN/m^2$
4. $1\ bar = 100\ kPa$
5. absolute temperature T(K)=t(deg C)+273.15
6. use SI units consistently
7. Q and W sign convention must be stated.

# How to Study This Book

## Exam Method: System Boundary, Sign Convention, Units and Checks

Start each mechanical-engineering problem by defining the system boundary, state points, sign convention and units. For thermodynamics, identify whether the system is closed or a control volume, then write the property and energy terms that can cross its boundary. Use absolute temperature in Carnot and entropy relations.

For flow, draw the control volume, state steady/incompressible assumptions, apply continuity first and then the energy equation with pumps, turbines and losses. Keep work and heat signs explicit. Check every formula against dimensions: enthalpy and internal energy are energy per unit mass, pressure head is P/γ, velocity head is V squared over 2g.

Treat reversible as an ideal limit, not as a synonym for adiabatic. In pipe systems, distinguish major friction loss from minor fitting loss and always identify the reference velocity. In MCQs, use assumptions and limiting cases to eliminate options before calculation.

Maintain an error log for Celsius-versus-Kelvin, specific-versus-total properties, heat/work signs, missing velocity head, and incorrect flow area. Re-solve errors after one day and one week.

# CHAPTER 1 — FUNDAMENTALS OF THERMODYNAMICS

## 1. Introduction

This chapter builds the language of thermodynamics: system, surroundings, boundary, properties, equilibrium, temperature, heat and work. These definitions prevent incorrect energy balances in real equipment.

## 2. Complete Theory

### Systems, properties and equilibrium

A system is closed, open/control volume or isolated. Properties are intensive or extensive; state depends only on properties, while heat and work are path functions.

Thermal, mechanical and phase equilibrium together define thermodynamic equilibrium. Engineering interpretation: this relationship is used to define a model boundary, select measurable variables and predict equipment performance.

The stated assumptions must be checked before using an ideal equation in a boiler, turbine, compressor, pump or pipeline. Exam perspective: identify the system, process and property basis before inserting numbers.

A correct formula with an incorrect boundary or sign convention gives a wrong engineering answer.

#### Hinglish Explanation

System ko boundary se separate socho. Property state ka address hai; heat/work journey ke according badalte hain.

Visualize the control surface and write what enters, leaves, is stored and is transferred. Pehle physical picture clear karo, phir formula lagao.

DSSSB mein definition ke saath assumption aur limiting case bhi poochha jaata hai.

### Temperature, zeroth law and pure substance

Zeroth law makes temperature measurable. A pure substance has fixed chemical composition and may be compressed liquid, saturated mixture, saturated vapour or superheated vapour.

Quality is vapour mass fraction in the two-phase region. Engineering interpretation: this relationship is used to define a model boundary, select measurable variables and predict equipment performance.

The stated assumptions must be checked before using an ideal equation in a boiler, turbine, compressor, pump or pipeline. Exam perspective: identify the system, process and property basis before inserting numbers.

A correct formula with an incorrect boundary or sign convention gives a wrong engineering answer.

#### Hinglish Explanation

Zeroth law thermometer ka base hai. Saturated dome ke andar liquid-vapour mixture hota hai; quality liquid fraction nahi, vapour mass fraction hai.

Visualize the control surface and write what enters, leaves, is stored and is transferred. Pehle physical picture clear karo, phir formula lagao.

DSSSB mein definition ke saath assumption aur limiting case bhi poochha jaata hai.

### Work and quasi-static processes

Boundary work is integral P dV for a quasi-static process. Isobaric, isochoric, isothermal, adiabatic and polytropic processes have distinct P-V paths.

Engineering interpretation: this relationship is used to define a model boundary, select measurable variables and predict equipment performance. The stated assumptions must be checked before using an ideal equation in a boiler, turbine, compressor, pump or pipeline.

Exam perspective: identify the system, process and property basis before inserting numbers. A correct formula with an incorrect boundary or sign convention gives a wrong engineering answer.

#### Hinglish Explanation

P-V curve ke niche area boundary work hai. Constant volume mein dV zero, so boundary work zero.

Visualize the control surface and write what enters, leaves, is stored and is transferred. Pehle physical picture clear karo, phir formula lagao.

DSSSB mein definition ke saath assumption aur limiting case bhi poochha jaata hai.

## 4. Engineering Formula Section

| Formula Sheet |
|---|
| 1. $P=F/A$ |
| 2. specific volume $v=V/m$ |
| 3. $Pv=RT$ |
| 4. $W_b$=integral P dV |
| 5. for constant pressure $W=P(V_2-V_1)$ |
| 6. for constant volume $W=0$ |
| 7. polytropic $PV^n=C$ |
| 8. $W=(P_{2V2}-P_{1V1})/(1-n)$ |

## 5. Formula Derivations and Solved Examples

Boundary work is obtained by dividing a quasi-static volume change into small elements dW=P dV and integrating along the actual path. Therefore work depends on path, unlike state properties. For constant volume dV=0 and boundary work is zero. For an ideal-gas polytropic process, substitute $P=CV^{-n}$ in integral P dV to obtain the standard work relation.

## 6. Practical Applications

- Power-plant cycle analysis.
- Boilers, turbines and compressors.

- Refrigeration and HVAC.
- Pumps, pipelines and water-supply systems.

## 7. Short Tricks

- State property depends on end states.
- P-V area is boundary work.
- Use Kelvin for absolute-temperature laws.

## 8. Concept Diagram

SYSTEM AND SURROUNDINGS
[ system ] | boundary | surroundings
Energy may cross as Q or W; mass crosses only an open boundary.

## 9. Comparison Table

| Term | Meaning | Exam check |
|---|---|---|
| State property | path independent | U,T,P,V |
| Path function | process dependent | Q,W |
| Closed system | no mass crossing | piston-cylinder |
| Control volume | mass crossing | turbine |

## 10. Common Mistakes

- Treating heat as stored property.
- Using boundary work without quasi-static pressure.
- Confusing system boundary with physical wall only.

## 11. Important DSSSB Exam Points

- System classification and work are direct questions.

## 12. Chapter Revision Sheet

Define the boundary first, then classify quantities as properties or path functions. Draw P-V paths before calculating work.

## 13. Practice Questions with Solutions

Attempt each question first. The explanation discusses only the correct answer.

**Q1. A closed system permits**

(A) energy transfer but not mass transfer
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mass is fixed.

**Q2. Zeroth law supports**

(A) temperature measurement
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Thermal equilibrium is transitive.

**Q3. Boundary work equals**

(A) integral P dV
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It is path area.

**Q4. At constant volume boundary work is**

(A) zero
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

dV is zero.

**Q5. A property is**

(A) path independent
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It belongs to state.

**Q6. A closed system permits**

(A) energy transfer but not mass transfer
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mass is fixed.

**Q7. Zeroth law supports**

(A) temperature measurement
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Thermal equilibrium is transitive.

**Q8. Boundary work equals**

(A) integral P dV
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It is path area.

**Q9. At constant volume boundary work is**

(A) zero
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

dV is zero.

**Q10. A property is**

(A) path independent
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It belongs to state.

**Q11. A closed system permits**

(A) energy transfer but not mass transfer
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mass is fixed.

**Q12. Zeroth law supports**

(A) temperature measurement
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Thermal equilibrium is transitive.

**Q13. Boundary work equals**

(A) integral P dV
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It is path area.

**Q14. At constant volume boundary work is**

(A) zero
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

dV is zero.

**Q15. A property is**

(A) path independent
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It belongs to state.

**Q16. A closed system permits**

(A) energy transfer but not mass transfer
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mass is fixed.

**Q17. Zeroth law supports**

(A) temperature measurement
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Thermal equilibrium is transitive.

**Q18. Boundary work equals**

(A) integral P dV
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It is path area.

**Q19. At constant volume boundary work is**

(A) zero
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

dV is zero.

**Q20. A property is**

(A) path independent
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It belongs to state.

Quick Revision: Re-read the formula box, cover the answers, and explain each exam point aloud. A formula is ready for the exam only when its symbols, SI units, assumptions and sign convention are clear.

# CHAPTER 2 — FIRST LAW, CONTROL VOLUME AND SFEE

## 1. Introduction

The first law is energy conservation applied to closed systems and flowing control volumes. It is the accounting framework for turbines, nozzles, compressors, boilers and heat exchangers.

## 2. Complete Theory

### First law, internal energy and enthalpy

For a closed system $\Delta U = Q - W$. Cycles have $\Delta U = 0$.

Enthalpy $h = u + Pv$ is useful for flowing fluids because $Pv$ represents flow work. Engineering interpretation: this relationship is used to define a model boundary, select measurable variables and predict equipment performance.

The stated assumptions must be checked before using an ideal equation in a boiler, turbine, compressor, pump or pipeline. Exam perspective: identify the system, process and property basis before inserting numbers.

A correct formula with an incorrect boundary or sign convention gives a wrong engineering answer.

#### Hinglish Explanation

First law energy bookkeeping hai. Cycle mein system state wapas same, isliye internal-energy change zero.

Visualize the control surface and write what enters, leaves, is stored and is transferred. Pehle physical picture clear karo, phir formula lagao.

DSSSB mein definition ke saath assumption aur limiting case bhi poochha jaata hai.

### Control volume and SFEE

At steady state, mass flow and energy storage do not change in a control volume. SFEE relates heat, shaft work, enthalpy, kinetic and potential energy per unit mass.

Engineering interpretation: this relationship is used to define a model boundary, select measurable variables and predict equipment performance. The stated assumptions must be checked before using an ideal equation in a boiler, turbine, compressor, pump or pipeline.

Exam perspective: identify the system, process and property basis before inserting numbers. A correct formula with an incorrect boundary or sign convention gives a wrong engineering answer.

#### Hinglish Explanation

Turbine, nozzle, compressor ko control volume banao. Inlet-outlet energy difference ke saath heat/work track karo.

Visualize the control surface and write what enters, leaves, is stored and is transferred. Pehle physical picture clear karo, phir formula lagao.

DSSSB mein definition ke saath assumption aur limiting case bhi poochha jaata hai.

## 4. Engineering Formula Section

| Formula Sheet |
|---|
| 1. $\Delta U=Q-W$ |
| 2. for cycle $Q_{net}=W_{net}$ |
| 3. $h=u+Pv$ |
| 4. SFEE: $q-w_s=(h_2-h_1)+(V_2^{2-V}{}_1^2)/2+g(z_2-z_1)$ |
| 5. $m_{dot}=\rho AV$ |
| 6. $C_p-C_v=R$ |

## 5. Formula Derivations and Solved Examples

Apply energy conservation to a control volume over a time interval. At steady state storage is zero. Divide the result by mass flow rate and combine internal energy with flow work Pv to form enthalpy h, giving SFEE. For an adiabatic turbine with negligible kinetic and potential changes, shaft work equals $h_1-h_2$.

## 6. Practical Applications

- Power-plant cycle analysis.
- Boilers, turbines and compressors.
- Refrigeration and HVAC.
- Pumps, pipelines and water-supply systems.

## 7. Short Tricks

- Closed system: use U.
- Flowing stream: use h.
- Cycle: $\Delta U=0$.

## 8. Concept Diagram

CONTROL VOLUME
m_dot,h_1,V_1 -> [ turbine/nozzle ] -> m_dot,h_2,V_2
Qdot and Wdot cross the control surface.

## 9. Comparison Table

| Device | Dominant SFEE term | Typical result |
|---|---|---|
| Turbine | enthalpy drop | work output |
| Compressor | enthalpy rise | work input |
| Nozzle | enthalpy to velocity | high V |
| Heat exchanger | heat between streams | small external work |

## 10. Common Mistakes

- Mixing total and specific energy.

- Dropping velocity term in nozzle.
- Wrong work sign.

## 11. Important DSSSB Exam Points

- SFEE device applications are high-yield.

## 12. Chapter Revision Sheet

Choose closed-system first law or SFEE from the boundary. Keep all energy terms on a stated per-unit-mass basis.

## 13. Practice Questions with Solutions

Attempt each question first. The explanation discusses only the correct answer.

**Q1. For a cycle Δ U is**

(A) zero
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It returns to initial state.

**Q2. Enthalpy is**

(A) u+Pv
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It includes flow work.

**Q3. Steady flow energy equation applies to**

(A) a control volume
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mass crosses boundary.

**Q4. Adiabatic turbine work mainly equals**

(A) enthalpy drop
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

KE/PE often negligible.

**Q5. Ideal gas relation is**

(A) $C_p$-$C_v$=R
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mayer relation.

**Q6. For a cycle Δ U is**

(A) zero
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It returns to initial state.

**Q7. Enthalpy is**

(A) u+Pv
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It includes flow work.

**Q8. Steady flow energy equation applies to**

(A) a control volume
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mass crosses boundary.

**Q9. Adiabatic turbine work mainly equals**

(A) enthalpy drop
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

KE/PE often negligible.

**Q10. Ideal gas relation is**

(A) $C_p$-$C_v$=R
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mayer relation.

**Q11. For a cycle Δ U is**

(A) zero
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It returns to initial state.

**Q12. Enthalpy is**

(A) u+Pv
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It includes flow work.

**Q13. Steady flow energy equation applies to**

(A) a control volume
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mass crosses boundary.

**Q14. Adiabatic turbine work mainly equals**

(A) enthalpy drop
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

KE/PE often negligible.

**Q15. Ideal gas relation is**

(A) $C_p$-$C_v$=R
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mayer relation.

**Q16. For a cycle Δ U is**

(A) zero
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It returns to initial state.

**Q17. Enthalpy is**

(A) u+Pv
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It includes flow work.

**Q18. Steady flow energy equation applies to**

(A) a control volume
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mass crosses boundary.

**Q19. Adiabatic turbine work mainly equals**

(A) enthalpy drop
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

KE/PE often negligible.

**Q20. Ideal gas relation is**

(A) $C_p - C_v = R$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mayer relation.

Quick Revision: Re-read the formula box, cover the answers, and explain each exam point aloud. A formula is ready for the exam only when its symbols, SI units, assumptions and sign convention are clear.

# CHAPTER 3 — SECOND LAW, ENTROPY AND CARNOT CYCLE

## 1. Introduction

The second law sets the direction of natural processes and the limit on heat-engine and refrigerator performance. Entropy quantifies energy dispersal and irreversibility.

## 2. Complete Theory

### Second law, entropy and Carnot

Kelvin-Planck and Clausius statements restrict energy conversion and are equivalent. Entropy is a property; generation is nonnegative.

Carnot cycle sets the maximum efficiency between two reservoirs. Engineering interpretation: this relationship is used to define a model boundary, select measurable variables and predict equipment performance.

The stated assumptions must be checked before using an ideal equation in a boiler, turbine, compressor, pump or pipeline. Exam perspective: identify the system, process and property basis before inserting numbers.

A correct formula with an incorrect boundary or sign convention gives a wrong engineering answer.

#### Hinglish Explanation

Second law batata hai ki heat ko 100 percent work banana possible nahi. Entropy generation irreversibility ka measure hai.

Visualize the control surface and write what enters, leaves, is stored and is transferred. Pehle physical picture clear karo, phir formula lagao.

DSSSB mein definition ke saath assumption aur limiting case bhi poochha jaata hai.

## 4. Engineering Formula Section

| Formula Sheet |
|---|
| 1. $eta_{Carnot}=1-T_L/T_H$ |
| 2. $COP_R=T_L/(T_H-T_L)$ |
| 3. $\Delta s=$integral delta $Q_{rev}/T$ |
| 4. $S_{gen}>=0$ |
| 5. closed-system entropy balance $\Delta S=$integral delta $Q/T+S_{gen}$ |
| 6. steady CV: sum $m_{dot}$ $s_{out}$-sum $m_{dot}$ $s_{in}=$sum $Qdot/T_b+S_{dotgen}$ |

## 5. Formula Derivations and Solved Examples

Carnot efficiency follows from reversible heat transfer $Q_H/T_H=Q_L/T_L$ and $eta=1-Q_L/Q_H$. Replacing $Q_L/Q_H$ by $T_L/T_H$ gives $eta_{Carnot}$. The entropy balance states that entropy change equals entropy transfer plus nonnegative generation; equality holds only for internally reversible operation.

## 6. Practical Applications

- Power-plant cycle analysis.
- Boilers, turbines and compressors.
- Refrigeration and HVAC.
- Pumps, pipelines and water-supply systems.

## 7. Short Tricks

- Carnot needs Kelvin.
- $S_{gen}=0$ only reversible limit.
- Engine rejects heat.

## 8. Concept Diagram

```
CARNOT HEAT ENGINE
T_H reservoir -> Q_H -> [engine] -> W
                     -> Q_L -> T_L reservoir
```

## 9. Comparison Table

| Process | Entropy generation | Reality |
|---|---|---|
| Reversible | zero | ideal limit |
| Irreversible | positive | real process |
| Isolated system | entropy nondecreasing | second law |

## 10. Common Mistakes

- Using Celsius in Carnot formulas.
- Calling adiabatic automatically isentropic.
- Using negative entropy generation.

## 11. Important DSSSB Exam Points

- Kelvin-Planck, Clausius and Carnot are direct.

## 12. Chapter Revision Sheet

Second law limits conversion of heat to work. Write entropy balances with transfer and generation separately.

## 13. Practice Questions with Solutions

Attempt each question first. The explanation discusses only the correct answer.

**Q1. Carnot efficiency is**

(A) $1-T_L/T_H$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Temperatures are absolute.

**Q2. Entropy generation is**

(A) nonnegative
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Second-law requirement.

**Q3. Kelvin-Planck forbids**

(A) complete cyclic heat-to-work conversion from one reservoir
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Heat rejection is necessary.

**Q4. Clausius forbids**

(A) cold-to-hot heat transfer without external effect
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Refrigerator needs work.

**Q5. A reversible process has**

(A) zero entropy generation
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Ideal limiting condition.

**Q6. Carnot efficiency is**

(A) $1-T_L/T_H$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Temperatures are absolute.

**Q7. Entropy generation is**

(A) nonnegative
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Second-law requirement.

**Q8. Kelvin-Planck forbids**

(A) complete cyclic heat-to-work conversion from one reservoir
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Heat rejection is necessary.

**Q9. Clausius forbids**

(A) cold-to-hot heat transfer without external effect
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Refrigerator needs work.

**Q10. A reversible process has**

(A) zero entropy generation
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Ideal limiting condition.

**Q11. Carnot efficiency is**

(A) $1-T_L/T_H$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Temperatures are absolute.

**Q12. Entropy generation is**

(A) nonnegative
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Second-law requirement.

**Q13. Kelvin-Planck forbids**

(A) complete cyclic heat-to-work conversion from one reservoir
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Heat rejection is necessary.

**Q14. Clausius forbids**

(A) cold-to-hot heat transfer without external effect
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Refrigerator needs work.

**Q15. A reversible process has**

(A) zero entropy generation
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Ideal limiting condition.

**Q16. Carnot efficiency is**

(A) $1-T_L/T_H$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Temperatures are absolute.

**Q17. Entropy generation is**

(A) nonnegative
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Second-law requirement.

**Q18. Kelvin-Planck forbids**

(A) complete cyclic heat-to-work conversion from one reservoir
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Heat rejection is necessary.

**Q19. Clausius forbids**

(A) cold-to-hot heat transfer without external effect
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Refrigerator needs work.

**Q20. A reversible process has**

(A) zero entropy generation
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Ideal limiting condition.

Quick Revision: Re-read the formula box, cover the answers, and explain each exam point aloud. A formula is ready for the exam only when its symbols, SI units, assumptions and sign convention are clear.

# CHAPTER 4 — PROPERTIES OF FLUIDS AND FLUID KINEMATICS

## 1. Introduction

Fluid mechanics begins with properties that describe resistance to deformation and kinematics that describes motion without considering the forces causing it.

## 2. Complete Theory

### Fluid properties and stresses

Fluids deform continuously under shear. Density, specific weight, viscosity, surface tension and compressibility describe behaviour.

Newtonian shear relation is $\tau=\mu\, du/dy$. Engineering interpretation: this relationship is used to define a model boundary, select measurable variables and predict equipment performance.

The stated assumptions must be checked before using an ideal equation in a boiler, turbine, compressor, pump or pipeline. Exam perspective: identify the system, process and property basis before inserting numbers.

A correct formula with an incorrect boundary or sign convention gives a wrong engineering answer.

#### Hinglish Explanation

Fluid static shear resist nahi karta. Viscosity internal friction hai; honey ki viscosity water se higher hoti hai.

Visualize the control surface and write what enters, leaves, is stored and is transferred. Pehle physical picture clear karo, phir formula lagao.

DSSSB mein definition ke saath assumption aur limiting case bhi poochha jaata hai.

### Kinematics and flow types

Velocity field gives fluid motion; acceleration has local and convective parts. Flow may be steady/unsteady, uniform/nonuniform, laminar/turbulent, compressible/incompressible and rotational/irrotational.

Engineering interpretation: this relationship is used to define a model boundary, select measurable variables and predict equipment performance. The stated assumptions must be checked before using an ideal equation in a boiler, turbine, compressor, pump or pipeline.

Exam perspective: identify the system, process and property basis before inserting numbers. A correct formula with an incorrect boundary or sign convention gives a wrong engineering answer.

#### Hinglish Explanation

Steady ka matlab point par time se velocity change nahi, uniform ka matlab space se change nahi. Dono same nahi.

Visualize the control surface and write what enters, leaves, is stored and is transferred. Pehle physical picture clear karo, phir formula lagao.

DSSSB mein definition ke saath assumption aur limiting case bhi poochha jaata hai.

### Continuity, potential and Euler

Mass conservation gives integral and differential continuity equations. Irrotational flow admits velocity potential.

Euler equation is momentum balance for ideal inviscid flow. Engineering interpretation: this relationship is used to define a model boundary, select measurable variables and predict equipment performance.

The stated assumptions must be checked before using an ideal equation in a boiler, turbine, compressor, pump or pipeline. Exam perspective: identify the system, process and property basis before inserting numbers.

A correct formula with an incorrect boundary or sign convention gives a wrong engineering answer.

#### Hinglish Explanation

Continuity mass ko create/destroy nahi hone deta. Area kam ho to incompressible flow velocity badhegi.

Visualize the control surface and write what enters, leaves, is stored and is transferred. Pehle physical picture clear karo, phir formula lagao.

DSSSB mein definition ke saath assumption aur limiting case bhi poochha jaata hai.

## 4. Engineering Formula Section

| Formula Sheet |
|---|
| 1. $\rho=m/V$ |
| 2. $\gamma=\rho\ g$ |
| 3. $SG=\rho/\rho_{water}$ |
| 4. $\tau=\mu\ du/dy$ |
| 5. $\nu=\mu/\rho$ |
| 6. $Re=\rho\ VD/\mu$ |
| 7. $Q=AV$ |
| 8. $m_{dot}=\rho\ AV$ |
| 9. local acceleration=partial V/partial t |
| 10. convective acceleration=(V dot grad)V |

## 5. Formula Derivations and Solved Examples

Newtonian viscosity is defined by proportionality between shear stress and velocity gradient. Continuity follows from conservation of mass: $\rho_{1A1V1}=\rho_{2A2V2}$, reducing to $A_{1V1}=A_{2V2}$ for incompressible steady one-dimensional flow.

## 6. Practical Applications

- Lubrication systems.
- Pump suction lines.
- Water and irrigation channels.
- HVAC ducts.

## 7. Short Tricks

- Re compares inertia with viscosity.
- A V constant only under stated incompressible steady conditions.

## 8. Concept Diagram

FLOW CLASSIFICATION
steady/unsteady | uniform/nonuniform
laminar/turbulent | rotational/irrotational
compressible/incompressible

## 9. Comparison Table

| Property | Meaning | Unit |
|---|---|---|
| Density | mass/volume | $kg/m^3$ |
| Viscosity | shear resistance | Pa s |
| Specific weight | weight/volume | $N/m^3$ |
| Kinematic viscosity | $\mu/\rho$ | $m^2/s$ |

## 10. Common Mistakes

- Confusing dynamic and kinematic viscosity.
- Calling steady flow uniform.
- Using diameter in place of area.

## 11. Important DSSSB Exam Points

- Properties, flow classification and continuity are common.

## 12. Chapter Revision Sheet

Define the fluid state, then classify flow before selecting a kinematic relation.

## 13. Practice Questions with Solutions

Attempt each question first. The explanation discusses only the correct answer.

**Q1. A fluid**

(A) deforms continuously under shear stress
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It cannot sustain static shear.

**Q2. Dynamic viscosity relates**

(A) shear stress and velocity gradient
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Newtonian law.

**Q3. Reynolds number compares**

(A) inertial and viscous effects
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Dimensionless ratio.

**Q4. Continuity incompressible steady**

(A) $A_{1V1}=A_{2V2}$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mass conservation.

**Q5. Velocity potential requires**

(A) irrotational flow
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Potential representation.

**Q6. A fluid**

(A) deforms continuously under shear stress
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It cannot sustain static shear.

**Q7. Dynamic viscosity relates**

(A) shear stress and velocity gradient
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Newtonian law.

**Q8. Reynolds number compares**

(A) inertial and viscous effects
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Dimensionless ratio.

**Q9. Continuity incompressible steady**

(A) $A_{1V1}=A_{2V2}$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mass conservation.

**Q10. Velocity potential requires**

(A) irrotational flow
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Potential representation.

**Q11. A fluid**

(A) deforms continuously under shear stress
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It cannot sustain static shear.

**Q12. Dynamic viscosity relates**

(A) shear stress and velocity gradient
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Newtonian law.

**Q13. Reynolds number compares**

(A) inertial and viscous effects
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Dimensionless ratio.

**Q14. Continuity incompressible steady**

(A) $A_{1V1}=A_{2V2}$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mass conservation.

**Q15. Velocity potential requires**

(A) irrotational flow
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Potential representation.

**Q16. A fluid**

(A) deforms continuously under shear stress
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

It cannot sustain static shear.

**Q17. Dynamic viscosity relates**

(A) shear stress and velocity gradient
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Newtonian law.

**Q18. Reynolds number compares**

(A) inertial and viscous effects
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Dimensionless ratio.

**Q19. Continuity incompressible steady**

(A) $A_{1V1}=A_{2V2}$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Mass conservation.

**Q20. Velocity potential requires**

(A) irrotational flow
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Potential representation.

Quick Revision: Re-read the formula box, cover the answers, and explain each exam point aloud. A formula is ready for the exam only when its symbols, SI units, assumptions and sign convention are clear.

# CHAPTER 5 — FLUID DYNAMICS, FLOW MEASUREMENT AND PIPE SYSTEMS

## 1. Introduction

Fluid dynamics connects motion with pressure and energy. Bernoulli, meters and pipe-loss relations are central to pumps, pipelines, irrigation, water supply and industrial flow systems.

## 2. Complete Theory

### Bernoulli and limitations

Bernoulli relates pressure, velocity and elevation heads along a streamline for steady incompressible inviscid flow. Real systems need head loss, pumps or turbines.

Engineering interpretation: this relationship is used to define a model boundary, select measurable variables and predict equipment performance. The stated assumptions must be checked before using an ideal equation in a boiler, turbine, compressor, pump or pipeline.

Exam perspective: identify the system, process and property basis before inserting numbers. A correct formula with an incorrect boundary or sign convention gives a wrong engineering answer.

#### Hinglish Explanation

Pressure head, velocity head aur elevation head energy forms hain. Real pipe mein friction loss add karna compulsory hai.

Visualize the control surface and write what enters, leaves, is stored and is transferred. Pehle physical picture clear karo, phir formula lagao.

DSSSB mein definition ke saath assumption aur limiting case bhi poochha jaata hai.

### Flow measurement

Venturimeter, orificemeter, nozzle meter and Pitot-static tube use pressure differences. Discharge coefficients correct ideal predictions for contraction and losses.

Engineering interpretation: this relationship is used to define a model boundary, select measurable variables and predict equipment performance. The stated assumptions must be checked before using an ideal equation in a boiler, turbine, compressor, pump or pipeline.

Exam perspective: identify the system, process and property basis before inserting numbers. A correct formula with an incorrect boundary or sign convention gives a wrong engineering answer.

#### Hinglish Explanation

Restriction velocity badhata aur pressure ghatata hai. Differential pressure se flow rate nikalte hain.

Visualize the control surface and write what enters, leaves, is stored and is transferred. Pehle physical picture clear karo, phir formula lagao.

DSSSB mein definition ke saath assumption aur limiting case bhi poochha jaata hai.

### Pipe flow and losses

Darcy-Weisbach gives major friction loss. Minor losses arise at entries, bends, valves, expansions and contractions.

EGL includes velocity head; HGL excludes it. Engineering interpretation: this relationship is used to define a model boundary, select measurable variables and predict equipment performance.

The stated assumptions must be checked before using an ideal equation in a boiler, turbine, compressor, pump or pipeline. Exam perspective: identify the system, process and property basis before inserting numbers.

A correct formula with an incorrect boundary or sign convention gives a wrong engineering answer.

**Hinglish Explanation**

Long straight pipe friction major loss hai; fittings minor kehlate hain, par many fittings mein total important ho sakta hai. Visualize the control surface and write what enters, leaves, is stored and is transferred.

Pehle physical picture clear karo, phir formula lagao. DSSSB mein definition ke saath assumption aur limiting case bhi poochha jaata hai.

## 4. Engineering Formula Section

| Formula Sheet |
|---|
| 1. Euler: $dP/\rho+V\,dV+g\,dz=0$ |
| 2. Bernoulli: $P/\gamma+V^2/(2g)+z=\text{constant}$ |
| 3. $h_f=fLV^2/(2gD)$ |
| 4. $h_m=KV^2/(2g)$ |
| 5. $C_d=Q_{actual}/Q_{theoretical}$ |
| 6. $HGL=z+P/\gamma$ |
| 7. $EGL=HGL+V^2/(2g)$ |

## 5. Formula Derivations and Solved Examples

Euler equation is Newton second law along a streamline for inviscid flow. Dividing by density and integrating yields Bernoulli when flow is steady and incompressible with no shaft work or losses. Venturimeter discharge follows continuity and Bernoulli between inlet and throat, then multiplies ideal result by $C_d$.

## 6. Practical Applications

- Venturi flow meters.
- Pipeline design.
- Hydropower penstocks.
- Pump and water-supply systems.

## 7. Short Tricks

- EGL-HGL=velocity head.

- Venturi loss less than orifice.
- Write continuity before Bernoulli.

## 8. Concept Diagram

EGL/HGL IN PIPE
EGL = z+P/gamma+V^2/(2g)
HGL = z+P/gamma
Losses cause both lines to fall downstream.

## 9. Comparison Table

| Device | Loss | Use |
|---|---|---|
| Venturimeter | low | accurate discharge |
| Orificemeter | higher | compact meter |
| Pitot | low | point velocity |
| Nozzle | moderate | robust flow meter |

## 10. Common Mistakes

- Applying Bernoulli without head losses.
- Ignoring reference velocity in minor loss.
- Mixing EGL and HGL.

## 11. Important DSSSB Exam Points

- Meters, Bernoulli assumptions and losses are high-yield.

## 12. Chapter Revision Sheet

State assumptions, use continuity, write energy equation with all heads, then add meter coefficients or pipe losses.

## 13. Practice Questions with Solutions

Attempt each question first. The explanation discusses only the correct answer.

**Q1. Bernoulli represents**

(A) energy conservation along a streamline
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Under ideal assumptions.

**Q2. Venturimeter measures**

(A) discharge from pressure difference
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Throat acceleration lowers pressure.

**Q3. Major loss is**

(A) $fLV^2/(2gD)$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Darcy-Weisbach form.

**Q4. Minor loss is**

(A) $KV^2/(2g)$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Fitting loss form.

**Q5. EGL exceeds HGL by**

(A) velocity head
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

V squared over 2g.

**Q6. Bernoulli represents**

(A) energy conservation along a streamline
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Under ideal assumptions.

**Q7. Venturimeter measures**

(A) discharge from pressure difference
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Throat acceleration lowers pressure.

**Q8. Major loss is**

(A) $fLV^2/(2gD)$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Darcy-Weisbach form.

**Q9. Minor loss is**

(A) $KV^2/(2g)$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Fitting loss form.

**Q10. EGL exceeds HGL by**

(A) velocity head
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

V squared over 2g.

**Q11. Bernoulli represents**

(A) energy conservation along a streamline
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Under ideal assumptions.

**Q12. Venturimeter measures**

(A) discharge from pressure difference
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Throat acceleration lowers pressure.

**Q13. Major loss is**

(A) $fLV^2/(2gD)$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Darcy-Weisbach form.

**Q14. Minor loss is**

(A) $KV^2/(2g)$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Fitting loss form.

**Q15. EGL exceeds HGL by**

(A) velocity head
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

V squared over 2g.

**Q16. Bernoulli represents**

(A) energy conservation along a streamline
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Under ideal assumptions.

**Q17. Venturimeter measures**

(A) discharge from pressure difference
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Throat acceleration lowers pressure.

**Q18. Major loss is**

(A) $fLV^2/(2gD)$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Darcy-Weisbach form.

**Q19. Minor loss is**

(A) $KV^2/(2g)$
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

Fitting loss form.

**Q20. EGL exceeds HGL by**

(A) velocity head
(B) Only the opposite process occurs
(C) It is always zero
(D) It is independent of assumptions

**Correct Answer: (A)**

V squared over 2g.

Quick Revision: Re-read the formula box, cover the answers, and explain each exam point aloud. A formula is ready for the exam only when its symbols, SI units, assumptions and sign convention are clear.