STUDY MATERIAL

SUBJECT : BASIC MECHANICAL ENGG.(BME)

MODULE-II

SEMESTER :1ST /2ND

(ALL BRANCHES)

CONTENTS :

- OBJECTIVE TYPE QUESTIONS AND ANSWERS
- SHORT TYPE QUESTIONS AND ANSWERS
- LONG TYPE QUESTIONS AND ANSWERS

DEPARTMENT OF MECHANICAL ENGINEERING

MULTIPLE CHOICE QUESTIONS

1. Device used to generate and supply steam at a high pressure and temperature is known as
   (a) steam injector (b) steam boiler
   (c) steam turbine (d) steam condenser
2. Fire tube boilers are
   (a) internally fired (b) externally fired
   (c) both (d) none of the above
3. Fire tube boilers are
   (a) Lanchashire boiler
   (b) Cochran boiler
   (c) locomotive boiler
   (d) all of the above
4. Number of fire tubes in Lanchashire boiler are
   (a) 1 (b) 2
   (b) 3 (d) 4
5. In a Lancashire boiler, the economiser is located
   (a) before air preheater
   (b) after air preheater
   (c) between feed pump and drum
   (d) all of the above
6. Locomotive boiler is
   (a) vertical, multitubular, fire-tube type
   (b) horizontal, multitubular, fire-tube type
   (c) horizontal, multitubular, water-tube type
   (d) none of the above
7. Water tube boiler is
   (a) Babcock and Wilcox boiler
   (b) Stirling boiler
   (c) Benson boiler
   (d) all of the above
8. Babcock and Wilcox boiler has water tubes
   (a) vertical (b) horizontal
   (c) inclined (d) none of the above
9. If circulation of water takes place by convection currents, set up during the heating of water, the boiler is known as
   (a) natural circulation boiler
   (b) forced circulation boiler
   (c) internally fired boiler
   (d) externally fired boiler
10. If circulation in boiler made by pump, then it is known as
   (a) natural circulation boiler
   (b) forced circulation boiler
   (c) internally fired boiler
   (d) externally fired boiler
11. If combustion takes place outside the boil water region, the boiler is known as
   (a) natural circulation boiler
   (b) forced circulation boiler
   (c) internally fired boiler
   (d) externally fired boiler
12. If combustion takes place inside the boi water region, the boiler is known as
   (a) natural circulation boiler
   (b) forced circulation boiler
   (c) internally fired boiler
   (d) externally fired boiler
13. In forced circulation boiler, force is applied t
   (a) draw water
   (b) drain off the water
   (c) circulate water
   (d) all of the above
14. Forced circulation boiler is
   (a) La-Mont boiler
   (b) Benson boiler
   (b) Loeffler boiler
   (d) all of the above
15. Safety valve used in locomotive boilers is
   (a) lever safety valve
   (b) dead weight safety valve
   (c) high steam and low water safety valve
   (d) spring loaded safety valve
16. A device used to empty the boiler, required and to discharge the mud, scale or ments collected at the bottom of the boil known as
   (a) safety valve (b) stop valve
   (b) fusible plug (d) blow off cock
17. An accessory of boiler is
   (a) feed pump
   (b) feed check valve
   (c) stop valve
   (d) blow off cock
18. A device used for recovery of waste heat o gas to heat the air before it passes into th nace is known as
   (a) super heater (b) air preheater
   (c) injector (d) economiser
19. Boiler mounting is
   (a) economiser (b) injector
   (c) fusible plug (d) super heater

20. Ratio of heat used in steam generation and heat supplied to the boiler is known as
    (a) boiler efficiency
    (b) chimney efficiency
    (c) economizer efficiency
    (d) none of the above
21. At very low temperature at which melting and boiling point of water becomes equal is
    (a) 233 K (b) 273.16 K
    (c) 303 K (d) 0 K
22. The critical pressure at which latent heat of vaporization of water becomes zero is
    (a) 225.65 bar (b) 273 bar
    (c) 100 bar (d) 1 bar
23. For water, below the atmospheric pressure
    (a) melting point rises slowly and boiling point drops markedly
    (b) melting point drops slowly and boiling point rises markedly
    (c) melting point rises slowly and boiling point rises markedly
    (d) none of these
24. The latent heat of steam at pressure greater than atmospheric pressure is
    (a) less (b) more
    (c) equal (d) none of these
25. The saturation temperature of steam with increasing pressure increases
    (a) linearly
    (b) first rapidly then slowly
    (c) inversely
    (d) none of these
26. Heating of dry steam above saturation temperature is known as
    (a) enthalpy
    (b) superheating
    (c) supersaturating
    (d) none of these
27. Superheating of steam is done at
    (a) constant volume
    (b) constant pressure
    (c) constant enthalpy
    (d) constant entropy
28. The specific volume of steam with increase in pressure decreases
    (a) linearly
    (b) slowly first and then rapidly
    (c) rapidly first and then slowly
    (d) inversely
29. If x_1 and x_2 be the dryness fractions obtained in separating calorimeter and throttling calorimeter, respectively, then the actual dryness fraction of steam will be
    (a) x_1x_2 (b) $x_1 + x_2$
    (c) $(x_1 + x_2)/2$ (d) x_1/x_2
30. The specific heat of superheated steam in kcal/kg is generally of the order of
    (a) 0.1 (b) 0.3
    (c) 0.5 (d) 0.8
31. A wet steam can be completely specified by
    (a) pressure only
    (b) temperature only
    (c) dryness fraction only
    (d) pressure and dryness fraction
32. On Mollier chart, the constant pressure lines
    (a) diverge from left to right
    (b) diverge from right to left
    (c) first rise up and then fall
    (d) none of these
33. On Mollier diagram, free expansion, or throttling process from high pressure to atmosphere is represented by
    (a) horizontal straight line
    (b) vertical straight line
    (c) curved line
    (d) none of these
34. Latent heat of dry steam at atmospheric pressure is equal to
    (a) 539 kcal/kg (b) 539 kJ/kg
    (c) 539 BTU/lb (d) none of these
35. In throttling process
    (a) entropy remains constant
    (b) enthalpy remains constant
    (c) pressure remains constant
    (d) none of these

Answers

1. (b), 2. (c), 3. (d), 4. (b), 5. (b), 6. (b), 7. (d), 8. (c), 9. (a), 10. (b), 11. (d), 12. (c), 13. (c), 14. (d), 15. (d), 16. (d), 17. (a), 18. (b), 19. (c), 20. (a), 21. (b), 22. (a), 23. (a), 24. (a),2 5(b), 26. (b), 27. (b), 28. (c), 29. (a), 30. (c), 31. (d), 32. (a), 33, (a), 34, (a), 35, (b)

FILL IN THE BLANKS

1. Water tube boilers produce steam at a __________ pressure than that of fire tube boilers.
2. For same dimensions and thickness of the tube, a water tube boiler has __________ heating surface than fire tube boiler.
3. A __________ in a boiler is used to put off fire in the furnace when the level of water falls to the unsafe limit.
4. An equivalent evaporation of a boiler is defined as __________.
5. The draught in locomotive boiler is produced by __________.

Answers

1. Higher, 2. More, 3. Fusible plug, 4. The amount of water evaporated from and at 100°C to dry and saturated steam, 5. Passing the steam through the furnace.

REVIEW QUESTIONS (Imp. Questions)

1. Define dryness fraction and degree of superheat and show their applications in steam power plant.
2. Explain the use of steam table and Mollier diagram.
3. Draw a neat sketch of throttling calorimeter and explain how dryness faction of steam is determined. Wha are its limitations?
4. What are the requirements for a good boiler?
5. Differentiate between
   (a) Natural circulation and forced circulation in boilers.
   (b) Internal fired and external fired boilers.
   (c) Fire tube and water tube boilers.
   (d) High pressure and low pressure boilers.
6. Explain very briefly the function of following mountings:
   (a) Steam stop valve (b) Feed check valve
   (c) Blow-off cock (d) Water level indicator
   (e) Pressure gauge (f) Safety valve
7. State the advantages of high pressure boilers. Explain the construction and working of Babcock ar Wilcox boiler with a neat sketch.
8. Explain the construction and working of pressure gauge with a neat sketch.
9. Explain the working of Cochran boiler and fusible plug with neat sketches.

MULTIPLE CHOICE QUESTIONS (Steam Turbines & Gas Turbines)

Steam Turbine

1. In an impulse turbine, steam expands
   (a) fully in nozzle
   (b) fully in blades
   (c) partly in nozzle and partly in blades
   (d) none of the above

2. In an impulse turbine, steam expands
   (a) fully in nozzle
   (b) fully in blades
   (c) partly in nozzle and partly in blades
   (d) none of the above

3. In impulse turbines, pressure on the two sides of the moving blades
   (a) increases (b) decreases
   (c) remains same (d) none of the above

4. In impulse turbine, when steam flows over the moving blades,
   (a) velocity decreases
   (b) velocity increases
   (c) pressure decreases
   (d) none of the above

5. In a reaction steam turbine, steam expands
   (a) in nozzle only
   (b) in moving blades only
   (c) partly in nozzle partly in blades
   (d) both in fixed and moving blades

6. De-Laval turbine is a
   (a) simple impulse turbine
   (b) simple reaction turbine
   (c) pressure compounded turbine
   (d) velocity compounded turbine

7. Parson's turbine is a
   (a) simple impulse turbine
   (b) simple reaction turbine
   (c) pressure compounded turbine
   (d) velocity compounded turbine

8. Curtis turbine is
   (a) simple impulse turbine
   (b) simple reaction turbine
   (c) pressure compounded turbine
   (d) velocity compounded turbine

9. Reteau turbine is
   (a) simple impulse turbine
   (b) simple reaction turbine
   (c) pressure compounded turbine
   (d) velocity compounded turbine

10. The turbine having identical fixed and moving blades is
    (a) de-laval turbine
    (b) parson's reaction turbine
    (c) rateau turbine
    (d) zoelly turbine

11. In reaction turbine, stage is represented by
    (a) each row of blades
    (b) number of casting
    (c) number of steam exits
    (d) none of the above

12. Blade efficiency is the ratio of
    (a) work done on blades and energy supplied to the blades
    (b) work done on blade and energy supplied to each stage

(c) energy supplied per stage and work done on the blades
(d) energy supplied to blades and work done on blades.

13. Maximum efficiency of Parson's reaction turbine is equal to

(a) $\frac{\cos^2\alpha}{1+2\cos^2\alpha}$ (b) $\frac{2\cos^2\alpha}{1+\cos^2\alpha}$

(c) $\frac{1+2\cos^2\alpha}{\cos^2\alpha}$ (d) $\frac{1+\cos^2\alpha}{2\cos^2\alpha}$

14. For maximum efficiency of a Parson's reaction turbine, the speed ratio is equal to

(a) $\frac{\cos\alpha}{2}$ (b) $\cos\alpha$

(c) $\cos^2\alpha$ (d) $\frac{\cos^2\alpha}{2}$

15. For maximum blade efficiency of a single stage impulse turbine, the blade speed is equal to

(a) $\frac{\cos\alpha}{2}$ (b) $\cos\alpha$

(c) $\cos^2\alpha$ (d) $\frac{\cos^2\alpha}{2}$

16. The compounding of turbine
(a) increases efficiency
(b) decreases rotor speed
(c) decreases exit loss
(d) all of the above

Gas Turbine

17. A gas turbine works on
(a) Rankine cycle (b) Carnot cycle
(c) Joule cycle (d) Ericsson cycle

18. When working fluid in a plant doesn't come in contact with the atmospheric air, and is used again, turbine is said to work on
(a) open cycle (b) closed cycle
(c) semi-closed cycle (d) none of these

19. When the entire fluid is taken from the atmosphere and is returned back to the atmosphere, the gas turbine is said to work on
(a) open cycle
(b) closed cycle
(c) semi-closed cycle
(d) none of these

20. Efficiency of closed cycle gas turbine as compared to open cycle gas turbine is
(a) more (b) less
(c) same (d) none of the above

21. Regenerator in gas turbine
(a) increases thermal efficiency
(b) decreases heat loss in exhaust
(c) allows use of higher compression ratio
(d) all of the above

22. Compressors used in turbine are
(a) reciprocating type
(b) centrifugal type
(c) axial flow type
(d) none of the above

23. Intercooling in gas turbine
(a) increases thermal efficiency
(b) decreases compression work
(c) increases turbine work
(d) none of the above

24. Reheating in turbine
(a) increases thermal efficiency
(b) decreases compression work
(c) increases turbine work
(d) none of the above

25. The air–fuel ratio in gas turbine is
(a) 15:1 (b) 30:1
(c) 45:1 (d) 50:1

26. The pressure ratio in gas turbine is of the order of
(a) 2:1 (b) 4:1
(c) 6:1 (d) 8:1

Answers

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

FILL IN THE BLANKS

1. The ratio of useful heat drop to isentropic heat drop is called ____.
2. De-Laval turbine is normally used for____ pressure and ____ speed.

3. The pressure–velocity compounded steam turbine allows a ____ pressure drop and hence____ number o stages are required.
4. In impulse-reaction turbine, the pressure drops gradually and continuously over____ blades.
5. The parson's reaction turbine has ____ and____ blades.
6. In reaction turbine, the degree of reaction is zero. This implies ____ heat drops in moving blades.

Answers

1. Reheat factor, 2. Low, High, 3. High, Less, 4. Fixed and Moving, 5. Identical fixed and moving, 6. Zero.

REVIEW QUESTIONS (Practice following Questions)

1. With a neat sketch explain the construction and working of a single stage impulse steam turbine.
2. What is compounding of impulse turbine? With a neat sketch explain the working of velocity compounding
3. With a neat sketch explain the working of pressure–velocity compounding of impulse steam turbine.
4. Differentiate impulse and reaction type steam turbines.
5. Write short notes on: (i) degree of reaction, (ii) reheat factor, (iii) diagram efficiency, and (iv) condition line
6. Explain the methods of governing of steam turbine.
7. Explain the working of closed cycle gas turbine.
8. Explain the working principle of open cycle as turbine.
9. What is a gas turbine? What are the essential components of a gas turbine plant? How it differs from a steam turbine?
10. What are the purposes of regeneration, intercooling, and reheating in a gas turbine?

PROBLEMS FOR PRACTICE (Imp. for Semester Exam)

1. In a single row impulse turbine, the blade speed is 200 m/s, nozzle angle is 18°. If the steam enters with absolute velocity of 300 m/s. Find
   (i) Inlet and outlet angles of moving blade so that there is no axial thrust.
   (ii) Power developed for a steam flow of 1 kg/s.
   (iii) Kinetic energy of steam leaving the stage.
2. A reaction turbine has degree of reaction 50% (i.e., Parson's reaction turbine) and running at 500 rpm develops 8 MW using 10 kg/kWh of steam flow rate. The exit angle of the blades is 18° and the velocity of steam relative to the blade at exit is two times the mean peripheral speed. At a particular stage in the expansion, the pressure is 1.2 bar and the steam quality is 90%.
   Calculate for the stage: (i) Blade height assuming the ratio of D_m/h_b as 12, and (ii) Diagram power.
3. In a four-stage turbine steam is supplied at 300 N/cm^2 and 380°C. The exhaust pressure is 0.05 N/cm^2 and the overall turbine efficiency is 0.7. Assuming that work is shared equally between stages and the condition line is a straight line, find (i) stage pressure, (ii) efficiency of each stage, and (c) reheat factor.
4. The enthalpy drop in the nozzle of an impulse turbine is 50 kJ/kg. The nozzle is inclined at 16° to the wheel tangent. The average diameter of the wheel is 0.25 m. Wheel runs at 11,000 rpm. Determine the blade inlet angle for sockless entry. If the blade exit angle is equal to the blade inlet angle, determine the work done/kg, and also the axial thrust for flow of 1 kg/s.

Imp. Notes

- The compression ratio of SI engines varies from 6 to 10 whereas in CI engines it ranges from 16 to 20.
- In a four stroke SI engine, there is one power stroke in two revolutions of crankshaft and two strokes, viz., suction and exhausts are non-productive.
- In two strokes of a spark ignition engine, the cycle of operations is completed in two strokes of the piston or one revolution of the crankshaft.
- SI engine is based on Otto cycle or constant volume heat addition and rejection cycle.
- CI engine is based on diesel cycle or constant pressure heat addition and constant volume heat rejection cycle.
- In Otto cycle, heat is added and rejected at constant volume.
- In diesel cycle, heat is added at constant pressure and is rejected at constant volume.
- Valve timing diagram is a graphical representation of valves opening and closing time with ignition time in terms of angle of crank revolution.
- For same compression ratio Otto cycle is more efficient but delivers less power than the diesel cycle. Therefore, in duel cycle partly heat is added at constant volume and partly at constant pressure.
- Indicated thermal efficiency is ratio of energy in the indicated diagram (I_p) to the input fuel energy.
- Brake thermal efficiency is ratio of energy in brake power (B_p) to the input fuel energy. Brake power is obtained by subtraction of friction losses from indicated power.
- Mechanical efficiency is ratio of the brake power to the indicated power.
- Volumetric efficiency is ratio of the volume of air inducted at ambient conditions to the swept volume of the engine.
- Relative efficiency or efficiency ratio is ratio of the thermal efficiency of actual cycle and the ideal cycle.
- Mean effective pressure is the average pressure inside the cylinder of an IC engine on the measured power output.

MULTIPLE CHOICE QUESTIONS

1. In I. C. engines, power developed inside the cylinder is known as
   (a) brake horse power
   (b) indicated horse power
   (c) pumping power
   (d) none of the above
2. The power spent in suction and exhaust strokes is known as
   (a) brake horse power
   (b) indicated horse power
   (c) pumping power
   (d) none of the above
3. The difference of total power produced and pumping power is known as
   (a) brake horse power
   (b) indicated horse power
   (c) net indicated horse power
   (d) none of the above
4. The power available at the shaft of an IC engine is known as
   (a) brake horse power
   (b) indicated horse power
   (c) net indicated horse power
   (d) none of the above
5. In a four stroke engine, the number of revolutions of the crankshaft for completion of working cycle is
   (a) one (b) two
   (c) three (d) four
6. In a two stroke engine, the number of revolutions of the crankshaft for completion of working cycle is
   (a) one (b) two
   (c) three (d) four
7. Theoretically, four stroke engine should develop power as compared to two stroke engine is
   (a) half (b) same
   (c) double (d) four times
8. At the same speed, the number of power strokes given by a two stroke engine as compared to a four stroke engine is
   (a) half (b) same
   (c) double (d) four times
9. Thermal efficiency of two stroke engine in comparison to four stroke engine is
   (a) more (b) same
   (c) less (d) none of the above

10. Mechanical efficiency of two stroke engine in comparison to four stroke engine is
    (a) more (b) same
    (c) less (d) none of the above
11. In a petrol engine, charge is ignited with
    (a) spark plug (b) compression
    (b) both (d) none of the above
12. In four stroke petrol engine,
    (a) intake valve closes after top dead centre
    (b) intake valve closed after bottom dead centre
    (c) exhaust valve closes after top dead centre
    (d) exhaust valve closes after bottom dead centre
13. Compression ratio in petrol engine ranges from
    (a) 6 to 10 (b) 10 to 15
    (c) 15 to 25 (d) 25 to 40
14. Compression ratio in diesel engine ranges from
    (a) 6 to 10 (b) 10 to 15
    (c) 14 to 22 (d) 25 to 40
15. If compression ratio in petrol engines is kept higher than that is in diesel engines, then
    (a) pre-ignition of fuel will occur
    (b) ignition of fuel will be delayed
    (c) detonation will occur
    (d) none of the above
16. In CI engines, the combustion is
    (a) homogeneous (b) heterogeneous
    (c) both (d) none of the above
17. Which of the following is not related to CI engine?
    (a) fuel pump (b) fuel injector
    (c) carburettor (d) flywheel
18. Indicator on an engine is used to determine
    (a) B.H.P (b) speed
    (c) temperature (d) I.H.P and m.e.p
19. Morse test is conducted on
    (a) vertical engines
    (b) horizontal engines
    (c) single cylinder engines
    (d) multi-cylinder engines
20. The m.e.p of a diesel engine with fixed compression ration can be improved by
    (a) increasing cut-off ratio
    (b) increasing back pressure
    (c) increasing operating pressure
    (d) reducing charge density

Answers

1. (b) 2. (c) 3. (c) 4. (a) 5. (b) 6. (a) 7. (a) 8. (c) 9. (c) 10. (a) 11. (a) 12. (b) 13. (a) 14. (c) 15. (a) 16. (b) 17. (c) 18. (d) 19. (d) 20. (a)

FILL IN THE BLANKS

1. An engine is said to be square if cylinder bores equal to ___________
2. The period during both inlet and exhaust valve remain open is known as ___________
3. A two stroke engine employs ___________ cut in the wall of cylinder instead of ___________
4. In four stroke petrol engine, size of intake valve is ___________ than that of exhaust valve.
5. Carburetion is the process of ___________ and ___________

Answers

1. Stroke length, 2. Valve overlap, 3. Ports, valves, 4. Smaller, 5. Mixing, vaporization of fuel.

MULTIPLE CHOICE QUESTIONS

1. Heat transfer takes place as per
   (a) zeroth law of thermodynamics
   (b) first law of thermodynamics
   (c) second law of thermodynamics
   (d) all the three

2. When heat is transferred from one particle of hot body to another by actual motion of the heated particles, it is referred to as heat transfer by
   (a) conduction (b) convection
   (c) radiation (d) none of these

3. When heat is transferred from hot body to cold body, in a straight line, without affecting the intervening medium, it is referred to as heat transfer by
   (a) conduction (b) convection
   (c) radiation (d) none of these

4. Heat transfer in liquids and gases takes place by
   (a) conduction (b) convection
   (c) radiation (d) none of these

5. When heat is transferred by molecular collision, it is referred to as heat transfer by
   (a) conduction (b) convection
   (c) radiation (d) none of these

6. Heat flows from one body to other when they have
   (a) different heat contents
   (b) different specific heat
   (c) different atomic structure
   (d) different temperature

7. The amount of heat flow through a body by conduction is
   (a) directly proportional to the surface area of the body
   (b) dependent upon material of the body
   (c) directly proportional to the temperature difference.
   (d) all the above

8. Thermal conductivity of a material may be defined as the
   (a) quantity of heat flowing in one second through one cubic metre of material when opposite faces are maintained at a temperature difference of 1°C.
   (b) quantity of heat flowing in 1 s through 1 m^2 of area and of 1 m thickness of material when opposite faces are maintained at a temperature difference of 1°C.
   (c) both
   (d) none of these

9. Heat transfer by radiation mainly depends upon
   (a) its temperature
   (b) nature of the body
   (c) kind and extent of its surface
   (d) all the above

10. If two surfaces of area A distance L apart, of a material having thermal conductivity k are at temperatures t_1 and t_2 then heat flow rate through it will be
    (a) $kA(t_1 - t_2)/L$ (b) $LA(t_1 - t_2)/k$
    (c) $Lk(t_1 - t_2)/A$ (d) None of these

11. According to Stefan's Law, the total radiation from a black body per second per unit area is proportional to
    (a) T (b) T^2 (c) T^3 (d) T^4

12. If the inner and outer surfaces of a hollow cylinder (having radii r_1 and r_2 and length L) are at temperature t_1 and t_2, then rate of radial heat flow will be
    (a) $\dfrac{k}{2\pi L}\cdot\dfrac{t_1 - t_2}{\log_e \dfrac{r_2}{r_1}}$ (b) $\dfrac{1}{2\pi kL}\cdot\dfrac{t_1 - t_2}{\log_e \dfrac{r_2}{r_1}}$
    (c) $\dfrac{2\pi L}{k}\cdot\dfrac{t_1 - t_2}{\log_e \dfrac{r_2}{r_1}}$ (d) $2\pi kL\cdot\dfrac{t_1 - t_2}{\log_e \dfrac{r_2}{r_1}}$

13. If the inner and outer walls of a hollow sphere having surface areas of A_1 and A_2, and inner and outer radii r_1 and r_2, are maintained at temperatures t_1 and t_2, then rate of heat flow will be
    (a) $k\sqrt{A_1A_2}\cdot\dfrac{t_1 - t_2}{r_2 - r_1}$ (b) $\dfrac{k}{\sqrt{A_1A_2}}\cdot\dfrac{t_1 - t_2}{r_2 - r_1}$
    (c) $\dfrac{4\pi k}{\sqrt{A_1A_2}}\cdot\dfrac{t_1 - t_2}{r_2 - r_1}$ (d) $\dfrac{4\pi k r_1 r_2}{\sqrt{A_1A_2}}\cdot\dfrac{t_1 - t_2}{r_2 - r_1}$

14. LMTD for a heat exchanger is given by
    (a) $\dfrac{\Delta t_2 - \Delta t_1}{\log_e \dfrac{\Delta t_2}{\Delta t_1}}$ (b) $\dfrac{\Delta t_2 - \Delta t_1}{\log_e \dfrac{\Delta t_1}{\Delta t_2}}$
    (c) both (d) none of these

15. The heat flow equation through a sphere of inner radius r_1 and outer radius r_2 is to be written in the same form as that for heat flow through a plane wall. For wall thickness $(r_2 - r_1)$, the equivalent mean radius for the spherical shell is
    (a) $\dfrac{r_1 + r_2}{2}$ (b) $r_1 r_2$
    (c) $\sqrt{r_1 r_2}$ (d) $\dfrac{r_1 + r_2}{\log_e (r_2/r_1)}$

Answers

1. (c), 2. (a), 3. (c), 4. (b), 5. (a), 6. (d), 7. (d), 8. (c), 9. (d), 10. (a), 11. (d), 12. (d), 13. (a), 14. (a), 15. (c).

Imp. Notes

- Within the refrigeration system, the expansion valve is located at the end of the liquid line, before the evaporator.
- By passing the liquid refrigerant from condenser through a heat exchanger through which the cold vapour at suction from the evaporator is allowed to flow in the reverse direction. This process sub-cools the liquid but superheats the vapour.
- If the vapour at the compressor entry is in the superheated state which is produced due to higher heat absorption in the evaporator, then the refrigerating effect is increased.
- The decrease in suction pressure decreases the refrigeration effect and at the same time increases the work of compression.
- The increase in discharge pressure results in lower COP.
- The factors like clearance volume, pressure drop through discharge and suction values, leakage of vapour along the piston and superheating of cold vapour due to contact with hot cylinder walls affects the volume of the vapour actually pumped by the compressor.
- Generally, two main types of room air conditioners are used—window and split air conditioner.

MULTIPLE CHOICE QUESTIONS

1. The cooling effect in refrigeration is obtained by
   (i) mechanical refrigeration technique
   (ii) passing direct current through junction of two dissimilar metals
   (iii) sublimation of carbon dioxide
   (iv) throttling of a real gas
   Which of the above statements are correct?
   (a) i and ii (b) i, ii and iii
   (c) i, ii and iv (d) i, ii, iii and iv
2. The cooling effect produced by refrigeration finds application in
   (i) construction of cold storages
   (ii) cooling of concrete in dams
   (iii) comfort air conditioning of hospitals
   (iv) liquidification of gases and vapours
   Select your answer from the following codes
   (a) i and iii (b) i, ii and iii
   (c) i, iii and iv (d) i, ii, iii and iv
3. A refrigeration system
   (a) removes heat from a system at low temperature and transfers the same to a system at high temperature
   (b) delivers less heat to the system at high temperature than it extracts from the system at low temperature
   (c) transfers heat from a high temperature source to a low temperature sink
   (d) violates second law of thermodynamics
4. The COP of a Carnot refrigeration cycle decreases on
   (a) decreasing the difference in operati[ng] temperatures
   (b) keeping the upper temperature constant a[nd] increasing the lower temperature
   (c) increasing the upper temperature a[nd] keeping the lower temperature constant
   (d) increasing the upper temperature a[nd] decreasing the lower temperature
5. A Carnot refrigerating cycle used in house [air] conditioning delivers heat to the surroundings [at] the rate of 10 kW of power. The coefficient [of] performance of this refrigerator would be
   (a) 1.5 (b) 1.67
   (c) 2.5 (d) 0.6
6. If a Carnot cycle is to have a coefficient [of] performance of 5, the ratio of maximum tem[perature] to minimum temperature in the cyc[le] should be
   (a) 1.2 (b) 1.5
   (c) 2.0 (d) 2.5
7. A Carnot refrigerator rejects 3,000 kJ of heat [at] 400 K while using 1,000 kJ of work. The lowe[st] operating temperature in the cycle should be
   (a) 15°C (b) 27°C
   (c) – 6°C (d) 0°C
8. A Carnot engine has an efficiency of 80%, if th[e] cycle is reversed in direction and made to ope[r]ate as a refrigerator, its COP will be
   (a) 0.25 (b) 0.5
   (c) 0.75 (d) 1.25

9. A condenser of a refrigeration system rejects heat at a rate of 120 kW, while its compressor consumes a power of 30 kW. The coefficient of performance of the system would be
   (a) 2 (b) 3
   (c) 4 (d) 5

10. The operating temperature of cold storage is 280 K and the heat leakage from the surroundings is 35 kW for the ambient temperature of 310 K. If the actual COP of the refrigeration plant is one fourth of an ideal plant working between the same temperature limits, the power required to drive the plant would be
   (a) 3.7 kW (b) 7.5 kW
   (c) 12 kW (d) 15 kW

11. A Carnot heat pump for domestic heating works between a cold system (the contents of refrigerator cabinet) at 0°C and the water in the radiator system at 80°C. The coefficient of performance of this heat pump would be about
   (a) 1.4 (b) 3.4
   (c) 4.4 (d) 6.212.

12. A heat pump working on a reversed Carnot cycle has a COP of 5. If it is made to work as a refrigerator taking 1 kW of work input, the refrigerating effect will be
   (a) 1 kW (b) 2 kW
   (c) 3 kW (d) 4 kW

13 The capacity of refrigerating m/c is expressed as
   (a) inside volume of cabinet
   (b) lowest temperature attained
   (c) gross wt. of m/c in tons
   (d) rate of abstraction of heat from the space being cooled

14. One TOR implies that the m/c has a refrigerating effect (capacity of heat extraction from the system being cooled) equal to
   (a) 50 kcal/s (b) 50 kcal/min
   (c) 50 kcal/h (d) 50 kcal/day

15. One TOR is equivalent to
   (a) 1 kW (b) 2.5 kW
   (c) 3.5 kW (d) 5 kW

16. The domestic refrigerator has a refrigerating load of the order of
   (a) less than 0.25 ton
   (b) between 0.5 and 1 ton
   (c) more than 1 ton
   (d) more than 5 ton

17. The refrigerating capacity of 165 domestic refrigerators is approximately equal to
   (a) 0.05 ton (b) 0.1 ton
   (c) 2 ton (d) 5 ton

18. Round the clock cooling of an apartment having a load of 300 MJ/day requires an air conditioning plant of capacity about
   (a) 1 ton (b) 5 ton
   (c) 10 ton (d) 25 ton

19. The refrigerating system of passenger air craft works on reversed
   (a) Brayton cycle (b) Atkinson cycle
   (c) Ericsson cycle (d) Carnot cycle

20. A Bell–Coleman cycle is a reversed
   (a) Brayton cycle (b) Atkinson cycle
   (c) Ericsson cycle (d) Carnot cycle

21. The Bell–Coleman refrigeration cycle uses ____ as working fluid.
   (a) hydrogen (b) carbon dioxide
   (c) air (d) any inert gas

Answers

1. (d) 2. (d) 3. (a) 4. (d) 5. (a) 6. (a) 7. (b) 8. (a) 9. (c) 10. (d) 11. (c) 12. (d) 13. (d) 14. (b) 15. (c) 16. (a) 17. (b) 18. (a) 19. (a) 20. (d) 21. (c)

C REVIEW QUESTIONS (Very Imp. for Semester Exam)

1. Differentiate the working of refrigeration and heat pump, thermodynamically.
2. Enumerate the various components used in a refrigerator and explain their working.
3. Write advantages and disadvantages of air refrigeration cycle.
4. Find the expression for COP using reversed Carnot cycle and Bell–Coleman cycle.
5. Find the derivation for COP in vapour compression cycle.

Imp. Notes

- An ideal fluid must be incompressible.
- In *Newtonian fluids* a linear relationship exists between the magnitude of the applied shear stress and th resulting rate of deformation.
- Surface tension is the tendency of the surface of a liquid to behave like a stretched elastic membrane.
- Surface tension may also be defined as the work (in Nm/m^2 or N/m) required to create unit surface area c the liquid.
- Capillarity is a phenomenon of rise or fall of liquid surface in a small tube relative to the adjacent gener level of liquid when the tube is held vertically in the liquid.
- The Bernoulli's equation is an approximate relation between pressure, velocity and elevation, and is valid regions of steady and incompressible flow where net frictional forces are negligible.
- Hydraulic machines are the devices that convert hydraulic energy into mechanical energy or mechanic energy into hydraulic energy.
- Hydraulic turbines are the basic prime movers which convert the hydraulic energy (in the form of pressur kinetic energy) into mechanical energy.
- Pump converts mechanical energy into hydraulic energy (pressure energy).
- Pelton turbine is named after L. A. Pelton an American Engineer; it is a high head, tangential flow, and lo specific speed turbine.
- Initially, Francis turbine was designed as a pure radial flow reaction turbine by an American Engine James B. Francis.
- Modern Francis turbine is mixed flow reaction turbine.
- A taper draft tube is used at the outlet of turbine to increase the head of water by the height of the draft tub
- Kaplan turbine is an axial flow, low head, high specific speed, reaction type turbine.
- Cavitation is defined as the phenomenon of formation of vapour bubbles due to fall in pressure below i vapour pressure and sudden bursting of these bubbles in a high pressure zone.
- Governing of turbines is required to control the speed of turbine.
- Centrifugal pump works on reverse of the principle of working of radial inward flow reaction turbine.
- In reciprocating pump this energy transformation is done by reciprocating action of piston.
- A gear pump maintains the flow of fluid by carrying the fluid between the teeth of two meshed gears.
- Hydraulic coupling is used to transmit the power from one shaft to another.

MULTIPLE CHOICE QUESTIONS

1. Fluid is a substance that
   (a) cannot be subjected to shear force
   (b) always expands until it fills any container
   (c) has the same shear stress at a point regardless of its motion
   (d) cannot remain at rest under action of any shear force
2. A fluid is said to be ideal, if it is
   (a) incompressible
   (b) inviscous
   (c) viscous and incompressible
   (d) inviscous and incompressible
3. The volumetric change of the fluid caused by a resistance is known as
   (a) volumetric strain
   (b) compressibility
   (c) adhesion
   (d) cohesion
4. Surface tension
   (a) acts in the plane of the interface normal any line in the surface
   (b) is also known as capillarity
   (c) is a function of the curvature of the interfa
   (d) decrease with fall in temperature
5. The stress--strain relation of the Newtonian fluid
   (a) linear (b) parabolic
   (c) hyperbolic (d) none of these
6. Unit of surface tension is
   (a) energy per unit area
   (b) force per unit length
   (c) both
   (d) none of these

7. Capillary action is due to the
   (a) surface tension
   (b) cohesion of the liquid
   (c) adhesion of the liquid molecules and the molecules on the surface of a solid
   (d) All of the above

8. The rise or fall of head h in a capillary tube of diameter d and liquid surface tension σ and specific weight w is equal to
   (a) $\frac{4\sigma}{wd}$ (b) $\frac{4d\sigma}{w}$
   (c) $\frac{4wd}{\sigma}$ (d) none of these

9. Cavitation will begin when
   (a) the pressure at any location reaches an absolute pressure equal to the saturated vapour pressure of liquid
   (b) pressure becomes more than critical pressure
   (c) flow is increased
   (d) pressure is increased

10. Bernoulli's theorem deals with the conservation of
   (a) mass (b) force
   (c) momentum (d) energy

11. Euler's equation in the differential form for motion of liquids is given by
   (a) $\frac{dp}{\rho} - gdz + vdv = 0$
   (b) $\frac{dp}{\rho} + gdz + vdv = 0$
   (c) $\frac{dp}{\rho} - gdz - vdv = 0$
   (d) $\frac{dp}{\rho} + gdz - vdv = 0$

12. A fluid which obeys $\mu = \frac{\tau}{du/dy}$
   (a) real fluid (b) perfect fluid
   (c) Newtonian fluid (d) none of these

13. The speed of turbine and discharge through turbine are proportional to
   (a) head, H (b) $\sqrt{H}$
   (c) H^2 (d) $H^{3/2}$

14. Specific speed of a turbine depends on
   (a) speed, power, and discharge
   (b) discharge and power
   (c) speed and head
   (d) speed, power, and head

15. An impulse turbine
   (a) operates submerged
   (b) requires draft tube
   (c) is nor exposed to atmosphere
   (d) operates by initial complete conversion to kinetic energy

16. A Pelton wheel is
   (a) tangential flow turbine
   (b) axial flow turbine
   (c) radial flow turbine
   (d) mixed flow turbine

17. Pelton wheels are used for minimum heads of
   (a) 20 m (b) 100 m
   (c) 125 m (d) 180 m

18. The ratio of width of bucket for a Pelton wheel to the diameter of jet is of the order of
   (a) 15 (b) 14
   (c) 13 (d) 12

19. Impulse turbine is used for
   (a) low head (b) high head
   (c) medium head (d) high flow

20. If α is the angle of blade tip at outlet, then maximum hydraulic efficiency of an impulse turbine is
   (a) $\frac{1+\cos\alpha}{2}$ (b) $\frac{1-\cos\alpha}{2}$
   (c) $\frac{1+\tan\alpha}{2}$ (d) $\frac{1-\tan\alpha}{2}$

21. Francis turbine is best suited for
   (a) medium head application (24–180 m)
   (b) low head installation (less than 30 m)
   (c) high head installation (more than 180 m)
   (d) none of these

22. In reaction turbine, draft tube is used
   (a) to transport water downstream without eddies
   (b) to convert the kinetic energy to pressure energy by a gradual expansion of the flow cross section
   (c) for safety of turbine
   (d) to increase flow rate

23. Francis, Kaplan and propeller turbines fall under the category of
   (a) impulse turbine (b) reaction turbine
   (c) axial-flow turbine (d) mixed flow turbine

24. For pumping viscous oil, the pump used is
   (a) centrifugal pump
   (b) reciprocating pump
   (c) screw pump
   (d) none of these

25. The work requirement of a reciprocating pump with increase in acceleration head
    (a) increases (b) decreases
    (c) remains same (d) none of these
26. To avoid cavitation in centrifugal pumps
    (a) suction pressure should be low
    (b) delivery pressure should be low
    (c) suction pressure should be high
    (d) delivery pressure should be high
27. Overall efficiency of centrifugal pump is equal to
    (a) volumetric efficiency × manimetric efficiency × mechanical efficiency
    (b) volumetric efficiency / manimetric efficiency × mechanical efficiency
    (c) volumetric efficiency × manimetric efficiency / mechanical efficiency
    (d) volumetric efficiency / manimetric efficiency / mechanical efficiency
28. The action of centrifugal pump is that of a
    (a) reaction turbine
    (b) impulse turbine
    (c) reverse of reaction turbine
    (d) none of these
29. In double acting reciprocating pump compared to single acting reciprocating pump will have nearly
    (a) double efficiency
    (b) double head
    (c) double flow
    (d) double weight
30. Specific speed of pump is
    (a) $\frac{N\sqrt{Q}}{H^{3/4}}$ (b) $\frac{N\sqrt{P}}{H^{5/4}}$
    (c) $\frac{N\sqrt{Q}}{H^{2/3}}$ (d) $\frac{N\sqrt{Q}}{H^{3/2}}$
31. Power required to drive a centrifugal pump is proportional to
    (a) impeller diameter (D)
    (b) D^2
    (c) D^3 (d) D^4
32. Power required to drive a centrifugal pump is proportional to
    (a) speed (N) (b) N^2
    (c) N^3 (d) N^4

Answers

1. (d), 2. (d), 3. (b), 4. (a), 5. (a), 6. (c), 7. (d), 8. (a), 9. (a), 10. (d), 11. (b), 12. (c), 13. (a), 14. (d), 15. (d), 16. (a), 17. (d), 18. (d), 19. (b), 20. (a), 21. (a), 22. (b), 23. (b), 24. (c), 25. (c), 26. (c), 27. (a), 28. (c), 29. (c), 30. (a), 31. (d), 32. (c)

REVIEW QUESTIONS (Practice These Questions)

1. What do you understand by fluid mechanics? How does it differ from mechanics of solid or mechanics of rigid body?
2. Classify the fluids based on their properties.
3. Derive the Bernoulli equation.
4. Derive the rise and fall of capillary action in a tube.
5. Derive an equation for pressure on a submerged body in a fluid.
6. What do you mean by a hydraulic turbine? How do you classify the hydraulic turbines?
7. Explain the working of Pelton turbine with a neat sketch.
8. Discuss the governing of Pelton turbine.
9. Derive the expression for work done and mechanical efficiency of Pelton turbines.
10. How does a hydraulic turbine differ from hydraulic pump?
11. What are the different types of efficiency of a turbine? Define each.
12. Draw inlet and outlet velocity triangle for Pelton turbine and find expression for hydraulic efficiency.

Imp. Notes

- In these compressors the pressure rise takes place due to the continuous conversion of angular momentum imparted to the gas by a high-speed impeller into static pressure.
- For backward curved vanes ($\beta < 90°$), the tangential component of absolute velocity is much reduced and consequently for a given impeller speed, the impeller will have a low energy transfer.
- For forward curved vanes ($\beta > 90°$), the tangential component of absolute velocity is increased and consequently the energy transfer for forward curved vane is maximum.
- In axial flow compressors, the flow proceeds throughout the compressor in a direction essentially parallel to the axis of the machine.
- Surging is caused due to unsteady, periodic and reversal flow of gas through the compressor when the compressor has to operate at less mass flow rate than a predetermined value.
- Choking occurs when mass flow rate reaches at maximum value when the pressure ratio becomes unity. This generally occurs when the Mach number (ratio of gas velocity and sound velocity) corresponding to relative velocity at inlet becomes sonic.
- The phenomenon of reduction in lift force at higher angles of incidence is known as stalling.

MULTIPLE CHOICE QUESTIONS

1. The most efficient method to compress the air is
   (a) isothermal compression
   (b) adiabatic compression
   (c) polytropic compression
   (d) none of these
2. Maximum work is done in compressing air when the compression is
   (a) isothermal compression
   (b) adiabatic compression
   (c) polytropic compression
   (d) none of these
3. Isothermal compression efficiency can be achieved by running the compressor
   (a) at very high speed
   (b) at very slow speed
   (c) at average speed
   (d) at zero speed
4. Aeroplane employs following type of compressor
   (a) reciprocating compressor
   (b) centrifugal compressor
   (c) axial flow compressor
   (d) none of these
5. The ratio of work done per cycle to the swept volume in case of compressor is called
   (a) compression ratio
   (b) compressor efficiency
   (c) mean effective pressure
   (d) none of these
6. Clearance volume in a cylinder should be
   (a) as large as possible
   (b) as small as possible
   (c) about 50% of swept volume
   (d) none of these
7. Clearance volume on a reciprocating compressor is required to
   (a) accommodate valves in cylinder head
   (b) provide cushioning effect
   (c) attain high volumetric efficiency
   (d) provide cushioning effect and also to avoid mechanical bang of piston with cylinder head
8. The net work input required for compressor with increase in clearance volume
   (a) increases (b) decreases
   (c) remain same (d) none of these
9. Volumetric efficiency is
   (a) the ratio of stroke volume to clearance volume
   (b) the ratio of air actually delivered to the amount of piston displacement
   (c) reciprocal of compression ratio
   (d) none of these
10. A compressor at high altitude will draw
    (a) more power (b) less power
    (c) same power (d) none of these
11. The machine run by prime mover and used to increase the air pressure is known as
    (a) steam turbine (b) gas turbine
    (c) compressor (d) IC engines
12. A compressor is used
    (a) in gas turbine plant
    (b) in supercharging IC Engines
    (c) in pneumatic drills
    (d) all off the above
13. Ratio of absolute discharge pressure to absolute inlet pressure is known as
    (a) compression ratio
    (b) expansion ratio

(c) compression efficiency
(d) compressor capacity

14. Compressor capacity is
(a) volume of air delivered
(b) volume of air sucked
(c) both (a) and (b)
(d) none of these

15. As the compression ratio increases, the volumetric efficiency of air compressor
(a) increases (b) decreases
(c) remain constant (d) none of these

16. In reciprocating compressor, clearance volume is provided to
(a) increase volumetric efficiency
(b) allow space for valves and to ensure that the piston does not strike the cylinder at the end of stroke
(c) decrease the work done
(d) all of these

17. The clearance volume in the compressor is kept minimum because it affects
(a) volumetric efficiency
(b) mechanical efficiency
(c) compressor efficiency
(d) isothermal efficiency

18. Ratio of isothermal horse power to the shaft horse power to drive a compressor is known as
(a) volumetric efficiency
(b) mechanical efficiency
(c) overall isothermal efficiency
(d) adiabatic efficiency

19. If k is the clearance ratio for a reciprocating air compressor, then volumetric efficiency will be
(a) $1 + k - K (P_2/P_1)^{1/n}$
(b) $1 - k + K (P_2/P_1)^{1/n}$
(c) $1 + k - K (P_1/P_2)^{1/n}$
(d) $1 - k + K (P_1/P_2)^{1/n}$

20. The optimum intermediate pressure P_2 in a two stage air compressor having P_1 and P_3 as suction and delivery pressures, respectively, is equal to
(a) $(P_1+P_2)/2$ (b) $P_1P_2/2$
(c) $(P_1+P_2)^{1/2}$ (d) $(P_1P_2)^{1/2}$

21. In multistage compression with intercooler, the compression obtained is
(a) isothermal (b) adiabatic
(c) polytropic (d) none of the above

22. Compressor in which compression is achieved by a rotating vane or impeller to give the air the desired pressure is known as
(a) single-stage compressor
(b) single-acting compressor
(c) rotary compressor
(d) reciprocating compressor

23. In gas turbine, type of compressor used is
(a) axial flow compressor
(b) reciprocating compressor
(c) centrifugal compressor
(d) all of the above

24. In centrifugal compressor, at a given pressure ratio an increase in speed causes
(a) increase in flow
(b) decrease in efficiency
(c) decrease in flow
(d) both (a) and (b)

25. In a centrifugal compressor, the pressure ratio can be increased by
(a) increasing tip speed
(b) decreasing inlet temperature
(c) both (a) and (b)
(d) none of the above

26. An axial flow compressor gives optimum performance at
(a) high speed (b) low speed
(c) moderate speed (d) none of the above

Answers

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

FILL IN THE BLANKS

1. A centrifugal compressor works on principle of conversion of _______.
2. A compressor at high altitude will draw _______.
3. The ratio of outlet whirl velocity to blade velocity in case of centrifugal compressor is called _______.

4. For high pressure compressors, _______ type of valve will be best suited.
5. The ratio of isentropic work to Euler work is known as _______.
6. Diffuser in compressor is used to _______.
7. Phenomenon of choking in compressor means _______.
8. Stalling of blades in axial flow compressor means _______.
9. Surging is the phenomenon of _______.
10. The maximum pressure ratio in single stage, single cylinder reciprocating compressor is _______.

Answers

1. Kinetic energy into pressure energy, 2. Less power, 3. Slip factor, 4. Poppet, 5. Pressure coefficient 6. Convert kinetic energy into pressure energy, 7. Fixed mass flow rate regardless of pressure ratio, 8. Air strean not able to flow the blade contour, 9. Unsteady, periodic and reverse flow, 10. 1:5

C REVIEW QUESTIONS (Practice following Questions)

1. What is function of compressor? How do you classify the compressors? Explain the various basis o classification.
2. Explain the assumptions of working of reciprocating compressor. Discuss the working of reciprocatin compressor with a neat sketch.
3. Derive the expression of work done by the compressor in isothermal compression, adiabatic compressio and polytropic compression.
4. Find the expression for volumetric efficiency of reciprocating compressor.
5. Discuss the assumptions and advantages of multistage compression.
6. Explain the working of fixed vane type and multiple vane type compressors.
7. Explain the working principle of centrifugal compressor.
8. Write short notes on surging, choking and stalling.

? PROBLEMS FOR PRACTICE (Imp. Questions For Semester Exam.)

1. A single-cylinder, single-acting air compressor has a cylinder diameter of 140 mm and stroke of 2,80 mm. It draws air into the cylinder at a pressure of 1 bar and temperature 27°C. This air is then compresse adiabatically to a pressure of 7 bar if the compressor runs at a speed of 120 rpm. Find
   (i) Mass of air compressed per cycle.
   (ii) Work required per cycle.
   (iii) Power required to drive the compressor.

   Neglect the clearance volume and take $R = 0.287$ kJ/kg K.
2. A single-stage reciprocating compressor is required to compress 1 kg of air from 1 to 8 bar. Initial temper ture of air is 20°C. Calculate work for isothermal, isentropic, and polytropic compression for $n = 1.25$.
3. A single-stage, single-acting air compressor has intake pressure of 1 bar and delivery pressure of 10 b: The compression and expansion follows the law $pV^{1.3}$ = constant. The piston speed and rotations of sh: is 200 m/min and 360 rpm, respectively. Indicated power is 40 kW and volumetric efficiency is 90% Determine the bore and stroke.

MODULE 2

Application of Thermodynamics and Introduction to Fluid Mechanics and Heat transfer

2.1 What is fluid mechanics?

Fluid mechanics is the science which deals with the mechanics of liquids and gases. It is divided into Fluid statics, Fluid kinematics and Fluid dynamics.

2.2 What is fluid?

A fluid is a substance that deforms continuously when subjected to a shear stress, no matter how small the shear stress may be. Fluid does not have its own shape but takes the shape of the vessel.

2.3 What are the types of fluids?

Fluids are classified as

1. Newtonian and Non Newtonian fluids 2. Ideal and real fluids.

2.4 State Newton's law of viscosity.

Newton's law of viscosity states that shear stress of a fluid is directly proportional to velocity gradient.

Shear stress $(\tau) \propto \frac{du}{dy}$ (Velocity gradient) (or) $\tau = \mu \frac{du}{dy}$, where 'μ' is Coefficient of viscosity.

2.5 What are Newtonian fluids? Give examples.

Fluids which obey Newton's law of viscosity (i.e.) fluids having linear relationship between shear stress and velocity gradient (deformation) are called Newtonian fluids. (eg) Water, Kerosene.

2.6 Distinguish between vapour and gas.

A vapour is a gas whose temperature and pressure are very closely near to the liquid phase. (eg). Steam

A gas may be defined as a highly super heated vapour, i.e. its state is far away from the liquid phase (eg) air.

2.7 Define density and specific weight.

Density is defined as mass per unit volume.

$$\text{Density } (\rho) = \frac{\text{Mass}}{\text{Volume}} \text{ kg/m}^3$$

Specific weight is defined as weight per unit volume.

$$\text{Sp.weight } (w) = \frac{\text{Weight}}{\text{Volume}} \text{ N/m}^3.$$

2.8 Define Specific volume and specific gravity.

Specific volume is the volume occupied by unit mass of fluid.

$$v = \frac{\text{volume of fluid}}{\text{Mass of fluid}} \text{ in m}^3\text{/kg} \; ; \; v = \frac{1}{\rho}$$

Specific gravity of any liquid is the ratio of its density to the density of standard liquid (water) at standard temperature.

$$\text{Specific gravity } (S) = \frac{\text{Density of liquid}}{\text{Density of Water}} = \frac{\rho}{\rho_w}$$

2.9 Define Compressibility and viscosity of fluid?

Compressibility is defined as the ratio of the change in pressure to the rate of change of volume due to the change in pressure.

$$\text{Compressibility} = \frac{1}{K}$$

$$(K = \text{Bulk Modulus})$$

$$K = \frac{\text{Compressive Strain}}{\text{Volumetric Strain}}$$

Viscosity is the resistance offered to the movement of one layer of fluid by another adjacent layer of the fluid.

$$\text{Viscosity } (\mu) = \frac{\text{Shear Stress}}{\left[\dfrac{\text{Change in velocity}}{\text{Change of distance}}\right]} = \frac{\tau}{du/dy}$$

This is generally called as dynamic viscosity.

2.10 What is Kinematic Viscosity?

Kinematic Viscosity is defined as ratio of dynamic viscosity to mass density

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

where ν: Kinematic viscosity

μ: Dynamic viscosity

ρ: Density of fluid.

2.11 Give the relationship between viscosity and temperature for liquids and gases and give its significance.

For liquid $\mu = \mu_o\left[\frac{1}{1+\alpha t+\beta t^2}\right]$. Viscosity for liquid decreases with increase in temperature.

For gas $\mu = \mu_o + \alpha t - \beta t^2$. Viscosity for gas increases with the increase in temperature.

Here, μ is viscosity of liquid / gas, μ_o is viscosity at 0°C and α, β are constants.

2.12 Why it is necessary in winter to use lighter oil for automobiles than in summer? To what property does the term lighter refer? (Anna Univ. Dec 2010)

For liquid viscosity $\mu = \mu_o\left[\frac{1}{1+\alpha t+\beta t^2}\right]$. In winter, temperature is low and hence the viscosity of the oil increases and hence in winter, lighter oil is used. The property referring to lighter is viscosity.

2.13 Define vapour pressure.

The partial pressure exerted by the vapour on the free surface of the liquid in a closed container is defined as vapour pressure.

2.14 Define Surface Tension. What is its unit?

Surface Tension in a liquid is a property due to cohesive force between the molecules of the same material or fluid. It is the rise or fall of free surface of liquid near the walls of the tube. Soap bubbles, droplets of water and dew on dry solid surface are due to surface tension. Its unit is N/m.

2.15 Give the equations for surface tension for soap bubble, liquid droplet and liquid jet.

The equation for surface tension for

Soap bubble : Pressure $(P) = \frac{8\,\sigma}{d}$

Liquid droplet : Pressure $(P) = \frac{4\,\sigma}{d}$

Liquid jet : Pressure $(P) = \frac{2\,\sigma}{d}$

Where P: Pressure in N/m^2, σ : Surface tension in N/m, d : Diameter in m.

2.16 A soap bubble is formed when the inside pressure is **5 N/m²** *above the atmospheric pressure. If surface tension in the soap bubble is 0.0125 N/m, find the diameter of bubble formed. (Anna Univ. Apr 2010)*

Given: Soap bubble $P = 5\ N/m^2$, $\sigma = 0.0125$ N/m

For Soap bubble $(P) = \frac{8\,\sigma}{d} \Rightarrow 5 = \frac{8 \times 0.0125}{d}$

$$d = \frac{8 \times 0.0125}{5} = 0.02 \text{ m}$$

$\therefore$ diameter (d) = 0.02m = 20 mm

2.17 Suppose the small air bubbles in a glass tap water may be on the order of **50 μ m** *in diameter, what is the pressure inside these bubbles.*

Given diameter $= 50\ \mu\, m = 50 \times 10^{-6}$ m

For liquid droplet $(P) = \frac{4\,\sigma}{d} = \frac{4 \times \sigma}{50 \times 10^{-6}} = 80{,}000\ \sigma$

$\therefore$ The pressure will be 80,000 times that of the surface tension.

suppose $\sigma = 0.1$ N/m, then pressure

$$= 0.1 \times 80{,}000 = 8000\ N/m^2$$

2.18 Define Capillarity.

Capillarity is a phenomenon of rise or fall of liquid surface relative to the adjacent general level of liquid. This phenomenon is due to the combined effect of cohesion and adhesion of liquid molecules. Rise of liquid is called capillary rise and fall is called capillary depression.

2.19 Define Pascal's law.

Pascal law states that the pressure P at a point in a fluid in equilibrium is same in all directions.

2.20 Define gauge pressure and vacuum pressure.

The pressure recorded by any pressure gauge, called gauge pressure, takes atmospheric pressure as datum and is measured either above or below atmospheric pressure.

Absolute pressure = Atmospheric ± gauge pressure.

'+' for gauge pressure (above atmospheric pressure).

'–' for negative gauge pressure (below atmospheric pressure).

2.21 Define Buoyancy

Buoyancy (also called **upthrust**) is the **upward force exerted by the fluid on an immersed body**.

Archimedes principle: Any body, wholly or partially immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the body.

Buoyant force = Weight of the fluid displaced by the body

2.22 What is the centre of Buoyancy?

Centre of Buoyancy (C_B)

The point through which the buoyant force is supposed to act is called the **centre of buoyancy**. It acts vertically upwards through the centre of gravity of the volume of fluid displaced.

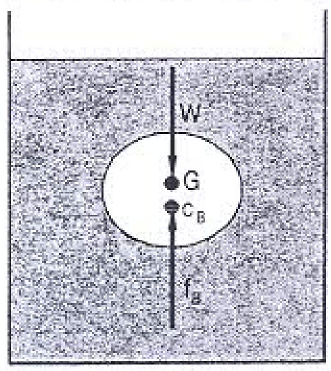

Fig:2.32(a) Force on a Body Immersed in a Fluid

2.23 How are water turbines classified?

(a) **Based on the action of water on the blades**

(i) Impulse turbine [Pelton wheel],

(ii) Reaction turbine [Francis, Kaplan, Propeller turbine]

(b) Based on the direction of fluid flow through the runner

(i) Tangential flow turbine [Pelton]

(ii) Radial flow — Inward flow / Outward flow

(iii) Mixed (or) diagonal flow turbine

(iv) Axial flow turbine [Kaplan & Propeller turbine]

2.24 How turbines are classified based on the head and specific speed?

(a) Based on the head

(i) Low head turbine [Kaplan]

(ii) Medium head turbine [Francis]

(iii) High head turbine [Pelton wheel]

(b) Based on specific speed

(i) Low specific speed turbine [$5 < N_S < 60$ – Pelton]

(ii) Medium specific speed turbine [$60 < Ns < 300$ – Francis]

(iii) High specific speed turbine [$Ns > 300$ – Kaplan]

2.25 Differentiate between turbine and pump.

	Turbine		**Pump**
(a)	Turbine is a power producing machine.	(a)	Pump is a pressure producing machine.
(b)	The available hydraulic energy of water is converted into mechanical energy	(b)	The mechanical energy available at the shaft is converted into hydraulic energy of water.
	e.g., Pelton wheel, Francis turbine, Kaplan turbine, etc.		e.g., Centrifugal pumps, Reciprocating pumps, *etc.*

2.26 Differentiate between inward and outward flow radial turbine.

In the inward flow radial turbine, water enters at the circumference of the runner and travels towards the axis and it discharges water radially at outlet.

In the outward flow radial turbine, water enters radially at the inlet of the runner and leaves circumferentially at outlet.

2.27 Define hydraulic efficiency, mechanical efficiency and overall efficiency.

(i) Hydraulic efficiency

$$= \frac{\text{Power developed by the turbine}}{\text{Power supplied at the inlet of the turbine}}$$

(ii) Mechanical efficiency

$$= \frac{\text{Power available at the shaft of the turbine}}{\text{Power developed by the turbine}}$$

(iii) Overall efficiency

$$= \frac{\text{Power available at the shaft of the turbine}}{\text{power supplied at the inlet of the turbine}}$$

$$\therefore \eta_0 = \eta_{hyd} \times \eta_{mech}$$

2.28 Francis turbine is an **inward flow** ***reaction turbine with*** radial ***discharge.***

Kaplan turbine is an axial flow turbine, in which the flow of water is parallel to the shaft.

2.29 Give important differences between Francis and Kaplan turbine.

	Francis		**Kaplan**
(i)	Fluid enters radially into the runner blades	(i)	Fluid enters axially (or) parallel to the axis of the shaft.
(ii)	Medium volume flow rate of fluid.	(ii)	It requires more volume flow rate.
(iii)	Medium head turbine.	(iii)	Low head turbine.
(iv)	Specific speed is moderate.	(iv)	More specific speed.

2.30 Compare Kaplan and Propeller turbines.

	Propeller Turbine		**Kalpan Turbine**
(a)	The blades are fixed on the hub and are not adjustable i.e., the blades are composite with the boss.	(a)	The blades are fixed on the hub (or) boss and are adjustable type.

2.31 Give differences between impulse and reaction turbine.

	Impulse Turbine	Reaction Turbine
(a)	Only kinetic energy of water is used to drive the runner shaft.	Both kinetic energy and pressure energy is used.
(b)	Draft tube is not required.	Draft tube is required.
(c)	Water flows through the nozzle and strikes the runner buckets.	Water is guided by the guide blades and flows over the moving blades.
(d)	All pressure energy is converted into kinetic energy.	Some amount of pressure energy is converted into kinetic energy.
(e)	Pressure drops in nozzles & not in moving blades.	Pressure drops in fixed blades as well as in moving blades.

2.32 Write a brief note on reaction turbine.

In a reaction turbine, the energy available at the inlet of the turbine is both kinetic energy and pressure energy.

2.33 Write a note on Hydraulic turbines.

Hydraulic turbines are defined as the hydraulic machines which convert hydraulic energy into usable mechanical energy as efficiently as possible. This mechanical energy is used for running an electric generators by which electrical energy is generated.

2.34 Name the main components of a reaction turbine.

(i) Spiral casing,

(ii) Guide mechanism,

(iii) Turbine Runner, and

(iv) Draft tube

2.35 Give important differences between Francis and Kaplan turbine.

	Francis	Kaplan turbine
1.	Fluid enters radially into the runner blades and leaves radially	Fluid enters and leaves axially (or) parallel to the axis of the shaft.
2.	Medium volume flow rate of fluid.	It requires more volume flow rate.
3.	Medium head turbine	Low head turbine.
4.	Specific speed is moderate	More specific speed.

2.36 What is a nozzle? Why it is used in pelton wheel?

Nozzle is a device which increase the velocity and decreases the pressure of the flowing fluid. It is used in pelton wheel to increase the kinetic energy of water before it strikes the buckets.

2.37 What are the functions of a draft tube?

The main functions of a draft tube are:

1. It converts the kinetic energy of water exhausted by the runner into pressure energy in the tube.
2. It enables the turbine to be placed above the tail race, so that the turbine may be inspected properly.
3. It increases the efficiency of the turbine.

2.38 Define a centrifugal pump.

The hydraulic machine which converts the mechanical energy into pressure energy by means of a centrifugal force is called centrifugal pump. It lifts water from a lower level into a higher level.

2.39 What are the applications of a centrifugal pump?

(i) water works

(ii) sewage works

(iii) irrigation

(iv) water pressure schemes

(v) drainage,

(vi) oil refineries, etc.

2.40 What are the functions of a casing in a centrifugal pump?

(i) It provides space for water coming out of the impeller and delivers it to the delivery pipe at constant velocity.

(ii) It converts a large portion of kinetic energy of water into pressure energy as the water flows through the casing.

(iii) It increases the efficiency by reducing the loss of head.

2.41 What are the types of casings generally used in centrifugal pumps?

The types of casings generally used are:

(i) Volute casing

(ii) Vortex (or) whirlpool casing and

(iii) Diffuser ring (or) Guide blade casing.

2.42 *Define suction and delivery head.*

The vertical height between the centre line of the centrifugal pump and the water surface in the sump is called suction head. Delivery head is the vertical distance between the centre line of the pump and the water surface in the tank to which water is lifted.

2.43 *Define static, manometric and gross head of a centrifugal pump.*

Static head is the vertical distance between the liquid surfaces in the sump and the tank to which the liquid is delivered by the pump. The sum of suction head and delivery head is known as "static head."

Manometric head or gross head is the actual head, against which the pump has to work. It includes friction head also.

2.44 *Compare centrifugal pump with reciprocating pump.*

	Centrifugal pump	Reciprocating pump
1.	Suitable for large discharge and smaller head.	Suitable for less discharge and higher heads.
2.	Air vessels are not required.	Air vessels are required.
3.	Its delivery is continuous.	Its delivery is pulsating.
4.	Needs priming	No need of priming

2.45 *Define reciprocating pump.*

Reciprocating pump is a device which converts the mechanical energy into hydraulic energy (pressure energy) by sucking the liquid into a cylinder in which a piston is reciprocating.

2.46 *What are the main parts of a reciprocating pump?*

The main parts of a reciprocating pump are.

1. A cylinder with a piston, piston rod, connecting rod & a crank.
2. Suction pipe,
3. Delivery pipe,
4. Suction valve, and
5. Delivery valve.

2.47 Differentiate single acting and double acting reciprocating pump.

	Single acting	Double acting
1.	Water is acting on one side of the piston only.	Water is acting on both sides of the piston.
2.	For one complete revolutions of the crank, water is delivered only one time in delivery pipe	For one complete revolution of the crank, water is delivered twice in delivery pipes.

2.48 Define slip of a reciprocating pump.

Slip of a pump is defined as the difference between the theorectical discharge and actual discharge of the pump.

$$\text{Slip} = Q_{Theoretical} - Q_{actual}$$

$$\text{Percentage of slip} = \left(\frac{Q_{th} - Q_{act}}{Q_{th}}\right) \times 100$$

The actual discharge of a pump is less than the theoretical discharge due to friction and leakage in the pipe.

2.49 Why compression ratio of petrol engines is low while diesel engines have high compression ratio?

In petrol engine, the compressed air-fuel mixture gets ignited by sparks produced by spark plug.

But in case of diesel engine, the compressed air should attain very high temperature in order to ignite injected diesel. Hence the air should be compressed to very high pressure. So the compression ratio is more in diesel engine than that of petrol engine.

2.50 Why for the same power CI engines are larger and heavier than SI engine?

In CI engine, the air is compressed to a very high pressure i.e the compression ratio in CI engine (diesel cycle) is more. To withstand the high pressure, the CI engines are larger and heavier.

2.51 What is meant by IC Engines?

If the combustion of fuel takes place inside the cylinder, then the engine is known as Internal Combustion Engines (or) IC Engines.

2.52 What are heat engines? Classify.

A type of engine or machine which derives heat energy from combustion of fuel or any other source and converts this energy into mechanical work is termed as Heat engines. They are classified as (i) External combustion engines (ii) Internal combustion engines (IC. Engines).

2.53 Classify I.C engines according to the cycle of combustion.

(i) Otto cycle engine

(ii) Diesel cycle engine

(iii) Dual combustion Engine.

2.54 Classify I.C engines according to the arrangement of cylinders.

(i) Horizontal engines (ii) Vertical engines

(iii) Radial engines (iv) V-type engines

2.55 Classify I.C engine according to the method of Ignition.

(i) Spark Ignition engines (S.I engines)

(ii) Compression Ignition engines (C.I engines)

2.56 What do you mean by scavenging in I.C Engines?

The process of removing burnt exhaust gases from the combustion chamber of engine cylinder is known as scavenging. Scavenging helps in reducing the dilution of fresh charge of mixture in the I.C. engines.

2.57 What is the purpose of Thermostat in an engine cooling system?

Whenever engine is started from cold, large amount of heat is required to attain its correct temperature (working). A thermostat prevents the flow of water below a certain temperature, from the engine to the radiator. It is a bellow type thermostat which maintains water at desired temperature.

2.58 What is the purpose of piston?

Piston is fitted to cylinder to receive gas pressure and transmit the force to the connecting rod.

2.59 What is the function of connecting rod?

Connecting rod transmits the piston load to the crank causing the latter to turn, thus converting the reciprocating motion of the piston into rotary motion of crankshaft.

2.60 What is the function of flywheel?

Flywheel stores energy required to rotate the shaft during preparatory strokes, provides uniform crankshaft rotation.

2.61 Explain Top Dead Centre and Inner Dead Centre.

The top most position of the piston towards the cover end side of the cylinder of a vertical engine is called Top Dead Centre (TDC) position.

In case of horizontal engines, this is known as Inner Dead Centre (IDC).

2.62 Explain Bottom Dead Centre and Outer Dead Centre.

The lowest position of the piston towards the crank end side of the cylinder of a vertical engine is known as Bottom Dead Centre (BDC) position.

In case of horizontal engines, this is known as Outer Dead Centre (ODC).

2.63 Explain 4 stroke cycle Engine.

The number of strokes required to complete the reciprocating engine cycle is four and hence the name is four stroke cycle.

The 4 strokes are

1. Suction stroke
2. Compression stroke
3. Power stroke
4. Exhaust stroke

2.64 What is the basic difference between Petrol engine and Diesel engine?

In general, four stroke Diesel engine is similar to the four stroke petrol engine in all aspects except that,

In Diesel engine,

- **'Fresh air'** is taken into the engine cylinder during suction stroke instead of **air-fuel mixture**.
- **'Fuel injector'** is fitted instead of **'spark plug'**.

2.65 What are the three ports of 2 stroke engine?

1. Inlet port
2. Exhaust port
3. Transfer port

2.66 Define Refrigeration.

Refrigeration is defined as the science of providing and maintaining temperature below surrounding atmosphere.

2.67 What is COP?

Coefficient of performance - COP - is the ratio of the desired effect (Refrigeration effect) to the work input.

2.68 What is the purpose of evaporator in refrigeration system?

While the low pressure and low temperature liquid refrigerant is passing through evaporator coil (cooling coil), it absorbs heat from the room (or) space to be cooled. As a result, the room gets cooled and the refrigerant gets heated, evaporated and becomes vapour.

2.69 What are the modes of heat transfer?

There are three modes of Heat transfer as follows:

1. Conduction
2. Convection
3. Radiation.

2.70 What is conduction?

Heat is always transferred by conduction from high temperature region to low temperature region. The conduction heat transfer is due to the property of matter and molecular transport of heat between two regions due to temperature difference.

When one end of a rod gets heated, the atoms in that end get enlarged and vibrated due to heating. The enlarged, vibrated atoms touch the adjacent atom and heat is transferred. Similarly, all the atoms are heated, thereby the heat is transferred to the other end. This type of heat transfer is called as conduction heat transfer.

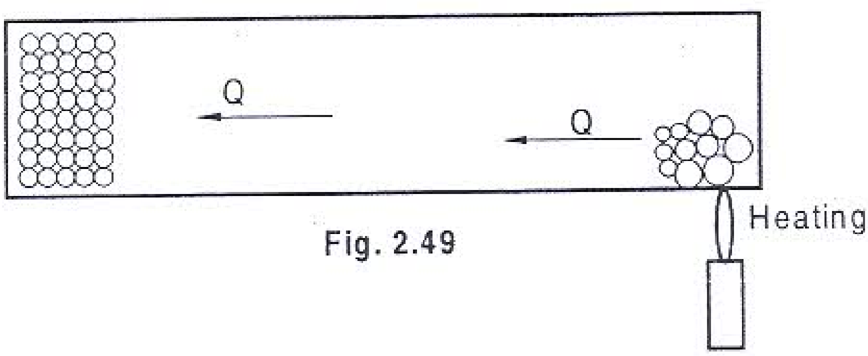

Fig. 2.49

2.71 Define Fourier's law of heat conduction.

Fourier's law states that the Conduction heat transfer through a solid is **directly proportional to**

1. The area of section (A) at right angle to the direction of heat flow.
2. The change in temperature (dT) inbetween the two faces of the slab and
3. **Indirectly proportional to** the thickness of the slab (dx).

$$Q \cdot \propto A \frac{dT}{dx}$$

where

Q = heat conducted in (Watts) W.

A = surface area of heat flow in m^2. (perpendicular to the direction of heat flow)

2.72 What is convection?

Convection is a mode of heat transfer occurring due to temperature difference between a surface and a moving fluid where the movement is created artificially or naturally.

There are two types.

1. Natural convection (or) Free convection.
2. Forced convection.

2.73 What is forced convection?

It is mode of heat transfer occurring due to temperature difference between a surface and a moving fluid, where the movement is generated by external force (such as blower and fan).

ex: heat transfer in superheater.

heat transfer in air preheater.

heat transfer in car radiator. (water pump and fan)

2.74 Define free convection.

It is mode of heat transfer occurring due to temperature difference between a surface and a moving fluid where the movement is generated by buoyancy force.

ex: heat transfer from electric bulb outer surface.

heat transfer during boiling water.

heat transfer from electric transformers.

2.75 What is thermal radiation?

Heat transfer by radiation is defined as the transfer of energy between surfaces by means of electromagnetic waves which is caused solely by a temperature difference. No medium is required for radiation.

Even in vacuum, radiation heat transfer takes place.

Propagation of internal energy of an emitting body through electromagnetic waves is known as *thermal radiation*. Electromagnetic waves are produced due to the electromagnetic disturbances originating in the emitting (radiating) body. The emitted electromagnetic waves propagate in vacuum at the speed of light. These electromagnetic waves are again converted into thermal energy and absorbed by other solids.

2.76 Write a short note on wave theory.

According to this theory, all space is filled up by ether. Each and every substance in earth makes wave motion in ether due to the vibration of its molecules. Radiation occurs by the propagation of these electromagnetic waves.

The speed of these electromagnetic waves is equal to the speed of light (3×10^8 m/s).

2.77 Write a short note on quantum theory: (postulated by planck).

According to this theory, when the temperature of body is raised, the atoms go to excited states. As a result, it emits energy in the form of electromagnetic radiation.

2.78 What is a heat exchanger?

Heat exchanger is used to transfer the heat between hot and cold fluids. Hot fluid may be cooled (or) cold fluid may be heated by the heat exchanger.

It is an equipment which transfers energy from hot fluid to cold fluid.

Example: Intercoolers, preheaters, condensers, boilers, radiators and evaporators.