Serial No. 53393

QUESTION BOOKLET

A

MECHANICAL ENGINEERING (05)

Time Allowed : 3 Hours
[1 Hour for Objective
2 Hours for Subjective]

Maximum Marks : 200
[100 Marks for Objective
100 Marks for Subjective]

INSTRUCTIONS FOR CANDIDATES

1. This Question Booklet consists of **two** Parts (Objective and Subjective). Candidate has to attempt both the Parts.
2. **In Objective Part, there are 50 questions carrying 2 marks each. There is no negative marking for any wrong answer. In Subjective Part, four (4) questions should be answered in which Question No. 1 is compulsory.**
3. Please do not open this Question Booklet until you are told to do so.
4. Candidate must fill up the necessary information in the space provided on the OMR Answer Sheet before commencement of the test.

5. For marking the correct answer, darken one circle by **black or blue** ball-point pen only. Please do not mark on more than one circle. Darkening on more than one circle against an answer will be treated as wrong answer.
6. Do not detach any leaf from this Question Booklet. After the examination, hand over the OMR Answer Sheet to the Room Invigilator.
7. Possession and use of Calculator, Mobile Phone and Pager is prohibited in the Examination Hall.
8. Candidates are informed that evaluation of OMR Sheets will be done by Electronic Machine. So, they should shadow the bubbles of Roll No., Booklet Series and Booklet No. properly, otherwise Machine will not be able to evaluate it. Failure to comply this instruction will be sole responsibility of the candidates.

SEAL

PART—A

(Objective)

1. Which of the following is an example of irreversible process?

(A) Polytropic expansion of fluid

(B) Unrestricted expansion of gases

(C) Isothermal expansion

(D) Electrolysis

2. A frictionless heat engine can be 100% efficient only if its exhaust temperature is

(A) equal to its input temperature

(B) less than its input temperature

(C) 0 °C

(D) 0 K

3. Which of the following is considered as thermodynamic potential?

(A) Temperature

(B) Internal energy

(C) Enthalpy

(D) Entropy

4. In a two-stage gas turbine plant with intercooling and reheating

(A) both work ratio and thermal efficiency improve

(B) work ratio improves but thermal efficiency decreases

(C) thermal efficiency improves but work ratio decreases

(D) both work ratio and thermal efficiency decrease

5. The specific heat relation is

(A) $C_p - C_V = \frac{\nu T \beta^2}{k}$

(B) $C_p - C_V = \frac{\nu T k}{\beta^2}$

(C) $C_p - C_V = \frac{pTk}{\beta^2}$

(D) $C_p - C_V = \frac{\nu^2 T \beta}{k}$

6. An ideal gas is heated from temperature T_1 and T_2 by keeping its volume constant. The gas is expanded back to its initial temperature according to the law $pV^n = c$. If the entropy change in the two processes are equal, then the value of n in terms of the adiabatic index ν is

(A) $n = \frac{\nu+1}{2}$ (B) $n = \frac{\nu-1}{2}$

(C) $n = \frac{\nu+2}{4}$ (D) $n = \frac{\nu+4}{2}$

7. The maximum percentage gain in regenerative feed heating cycle, the thermal efficiency

(A) increases with number of feed heaters increasing

(B) decreases with number of feed heaters increasing

(C) remains same unaffected by number of feed heaters

(D) None of the above

8. A Carnot engine, working between 400 °C and 40 °C, produces 130 kJ of work. The entropy change during heat rejection process is

(A) 113 kJ

(B) 133 kJ

(C) 131 kJ

(D) 123 kJ

9. Mole fraction of a component of gas mixture is equal to

(A) $\frac{1}{f}$

(B) f^2

(C) f

(D) $\frac{f}{p}$

where,

f = volume fraction

p = pressure of the mixture

10. When the fuel is burned and water is released in the liquid phase, the heating value of fuel is called

(A) higher heating value

(B) lower heating value

(C) enthalpy of formation

(D) None of the above

11. The mass of excess air supplied is equal to

(A) $\frac{23}{100}$ × mass of excess carbon

(B) $\frac{23}{100}$ × mass of excess oxygen

(C) $\frac{100}{23}$ × mass of excess carbon

(D) $\frac{100}{23}$ × mass of excess oxygen

12. In an Otto cycle, the temperature at the beginning and end of the isentropic compression are 316 K and 596 K respectively. The compression ratio will be

(A) 4·588

(B) 4·858

(C) 4·885

(D) 4·558

13. For the same maximum pressure and temperature of Otto, diesel and dual combustion air standard cycles

(A) the compression ratios will be the same

(B) the heat supplied to the cycles will be the same

(C) the air standard efficiency will have the same value

(D) the heat rejected by the engine will be the same

14. Which one of the following is not the chief effect of detonation?

(A) A loud pulsating noise which may be accompanied by a vibration of the engine

(B) A loud pulsating noise from the wheel assembly

(C) An increase in the heat lost to the surface of combustion chamber

(D) An increase in carbon deposits

15. A single-cylinder, two-stroke petrol engine develops 4 kW indicated power. If the mean effective pressure is 6·5 bar and piston diameter is 100 mm, the average speed of the piston is

(A) 23·5 m/s

(B) 47 m/s

(C) 94 m/s

(D) 186 m/s

16. The smallest quantity of a substance, which can exist by itself in a chemically recognizable form, is known as

(A) element

(B) compound

(C) atom

(D) molecule

17. The locomotive boiler has

(A) 137 fire tubes and 44 superheated tubes

(B) 147 fire tubes and 34 superheated tubes

(C) 157 fire tubes and 24 superheated tubes

(D) 167 fire tubes and 14 superheated tubes

18. In a boiler, various heat losses take place. The biggest loss is due to

(A) moisture in fuel

(B) dry flue gases

(C) steam formation

(D) unburnt carbon

19. The missing equality per stroke is equal to

(A) cylinder feed – indicated mass of steam

(B) cylinder feed + indicated mass of steam

(C) mass of cushion steam + indicated mass of steam

(D) mass of cushion steam – cylinder feed

20. The critical pressure ratio for initially dry saturated steam is

(A) 0·528

(B) 0·546

(C) 0·577

(D) 0·582

21. De-Laval turbines are mostly used

(A) where low speeds are required

(B) for small power purposes and low speeds

(C) for small power purposes and high speeds

(D) for large power purposes

22. In a reaction turbine, when the degree of reaction is zero, then there is

(A) no heat drop in the moving blades

(B) no heat drop in the fixed blades

(C) maximum heat drop in the moving blades

(D) maximum heat drop in the fixed blades

23. The purpose of governing in steam turbine is to

(A) reduce the effective heat drop

(B) reheat the steam and improve its quality

(C) completely balance against end thrust

(D) maintain the speed of the turbine

24. The reheat factor depends upon

(A) initial pressure and super-heat

(B) exit pressure

(C) turbine stage efficiency

(D) All of the above

25. The maximum efficiency of a reaction turbine is

(A) $\frac{2\sin^2\alpha}{1+\sin^2\alpha}$

(B) $\frac{1+\sin^2\alpha}{2\sin^2\alpha}$

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

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

where, α = nozzle angle

26. A single-stage reciprocating air compressor is required to compress 1 kg of air from 1 bar to 4 bar. The initial temperature is 27 °C. The work developed during isentropic compression is

(A) 146·96 kJ

(B) 146·04 kJ

(C) 146·63 kJ

(D) 146·89 kJ

27. What is the minimum work required to compress 1 kg of air from 1 bar, 27 °C to 16 bar in two stages, if the law of compression is $pV^{1.25}$ = constant and the inter- cooling is perfect?

[Take : $R = 287$ J / kg-K]

(A) 275·09 kN-m

(B) 175·09 kN-m

(C) 375·09 kN-m

(D) 475·09 kN-m

28. The compressor mostly used for supercharging of IC engine is a/an

(A) radial-flow compressor

(B) axial-flow compressor

(C) roots blower

(D) reciprocating compressor

29. The region outside the Mach cone is called

(A) zone of action

(B) zone of silence

(C) control volume

(D) None of the above

30. A Parson's turbine is also known as

(A) 25% reaction turbine

(B) 50% reaction turbine

(C) 75% reaction turbine

(D) impulse turbine

31. Reheating in a gas turbine

(A) increases thermal efficiency

(B) increases compressor work

(C) increases turbine work

(D) decreases thermal efficiency

32. Which one of the following is the expression of stock strength?

(A) $\frac{2\nu}{\nu+1}[m_1^2 - 1]$

(B) $\frac{\nu+1}{2\nu}[m_1^2 - 1]$

(C) $\frac{2\nu}{\nu-1}\frac{1}{[m_1^2 - 1]}$

(D) $\frac{\nu+1}{2\nu}\frac{1}{[m_1^2 - 1]}$

33. The flow of steam is supersonic

(A) at the entrance to the nozzle

(B) at the throat of the nozzle

(C) in the convergent portion of the nozzle

(D) in the divergent portion of the nozzle

34. The boiling point of carbon dioxide is

(A) – 20·5 °C

(B) – 50 °C

(C) – 73·6 °C

(D) – 78·3 °C

35. A bootstrap air-cooling system has

(A) one heat exchanger

(B) two heat exchangers

(C) three heat exchangers

(D) four heat exchangers

36. Most air-cooled condensers are designed to operate with a temperature difference of

(A) 5 °C

(B) 8 °C

(C) 14 °C

(D) 22 °C

37. The pressure at the inlet of a refrigerant compressor is called

(A) suction pressure

(B) discharge pressure

(C) critical pressure

(D) back pressure

38. A long pipe of 0·6 m outside diameter is buried in earth with axis at a depth of 1·8 m. The surface temperatures of the pipe and the centre are 95 °C and 25 °C respectively. The conductivity of the centre is 0·51 W/m °C. The heat loss from the pipe per meter length is

(A) 90·25 W

(B) 45·125 W

(C) 180·50 W

(D) 100 W

39. The thickness of thermal and hydrodynamic boundary layers is equal, if

(A) $pr = 1$

(B) $pr > 1$

(C) $pr < 1$

(D) $pr = Nu$

40. The rate of heat transfer from a solid surface to a fluid is obtained from

(A) Newton's law of cooling

(B) Fourier's law

(C) Kirchhoff's law

(D) Stefan's law

41. Transmission of heat by molecular collision is

(A) scattering

(B) conduction

(C) convection

(D) radiation

42. Least value of Prandtl number can be expected in case of

(A) water

(B) liquid metals

(C) salt solution

(D) sugar solution

43. The buoyant force acting on a floating body passes through

(A) metacentre of the body

(B) CG of the body

(C) centroid of the volume of the body

(D) centroid of the displaced volume

44. A reservoir having a surface area of 500 m^2 is emptied by a 0·5 m wide rectangular weir. How long should it take to empty the reservoir from a height of 3·2 m to 0·1 m above the sill?

[Take : $C_d = 0 \cdot 65$]

(A) 16 minutes and 5 seconds

(B) 8 minutes and 5 seconds

(C) 32 minutes and 5 seconds

(D) 10 seconds

45. A rectangular channel of 4 m width conveys water at 8 m^3/sec under critical condition. The specific energy for this flow is

(A) 1·1123 m

(B) 1·4830 m

(C) 0·3703 m

(D) 0·7416 m

46. Which one of the following is dimensionless?

(A) $\frac{\partial P}{\partial x} \cdot \frac{D^4}{\mu Q^2}$

(B) $\frac{\partial P}{\partial x} \cdot \frac{D^3}{\mu Q}$

(C) $\frac{\partial P}{\partial x} \cdot \frac{D^4}{\mu Q}$

(D) $\frac{\partial P}{\partial x} \cdot \frac{\mu Q}{D^4}$

47. If it is required to convey the same discharge by replacing a pipe of diameter D by two equal parallel pipes of diameter d each, then $\frac{d}{D}$ should be

(A) 0·37

(B) 0·42

(C) 0·50

(D) 0·76

48. The critical angle of attack of an aerofoil is that, where

(A) the lift becomes zero

(B) the drag becomes zero

(C) the drag begins to rise

(D) the lift begins to drop

49. For laminar flow in a round pipe, the energy correction factor is

(A) 0·50

(B) 1·00

(C) 1·33

(D) 2·0

50. The velocity gradient in the transverse direction for a fluid flow equals

(A) the pressure gradient in the flow

(B) the rate of shear strain

(C) the stress at that point

(D) the strain at that point

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MECHANICAL ENGINEERING (05)

PART—B

(Subjective)

Full Marks : 100 *Time* : 2 hours

The figures in the margin indicate full marks for the questions

Candidates are required to answer **four** questions of which Question No. **1** is compulsory

1. Answer any *five* of the following questions : 5×5=25

(a) Air expands through a turbine from 500 kPa, 520 °C to 100 kPa, 300 °C. During expansion 10 kJ/kg of heat is lost to the surroundings which is at 98 kPa, 20 °C. Neglecting the KE and PE changes, determine the work done by the turbine.

[Assume $C_p = 1{\cdot}005$ kJ/kg-K, mass flow rate = 1 kg/s]

(b) Draw the *P-V* and *T-S* diagrams of a diesel cycle and indicate all the processes in it.

(c) What is a heat pump? Define its COP. Compare the COP of a heat pump with that of a refrigerator.

(d) Draw the typical valve timing diagrams for four-stroke SI and CI engines.

(e) State any five differences between turbojet and turboprop engines.

(f) Sketch and explain the Bell Coleman cycle of refrigeration and deduce an expression for the COP of the cycle.

(g) With neat sketches, explain the following types of heat exchangers :

Double pipe—parallel flow and counter flow

Also show the temperature profiles for them.

(h) How are hydraulic turbines classified? Explain in detail.

2. *(a)* A cylinder contains $0 \cdot 5\ m^3$ of a gas at 0·1 MPa and 90 °C. The gas is compressed to a volume of $0 \cdot 125\ m^3$. The final pressure is 600 kPa. Determine the work done and the change in entropy of the gas during the process. [Assume $R = 0 \cdot 287$ kJ/kg-K and $C_v = 0 \cdot 713$ kJ/kg-K] 15

(b) Explain an Otto cycle. Draw a *P-V* diagram of Otto cycle and explain each of the four operations completing the cycle. 10

3. *(a)* An air compressor takes in air at 100 kPa, 17 °C and delivers it at 1 MPa, 600 K to a constant pressure cooler, which it exits at 300 K. Making suitable assumptions, find the specific compressor work and the specific heat transfer. [Assume for air $R = 0 \cdot 287$ kJ/kg-K and $\gamma = 1 \cdot 4$] 13

(b) How are the compressors classified? Discuss the merits and demerits of rotary compressors over reciprocating compressors. 12

4. The following data pertains to a 4-cylinder, 4-stroke SI engine :

$D = 6 \cdot 5$ cm, $L = 9 \cdot 5$ cm, $N = 3000$ r.p.m., $V_c = 65\ cm^3$, relative efficiency based on BTE= 50%, calorific value of fuel = 41800 kJ/kg

When tested on load, it developed 69 N-m torque

Assuming the mechanical efficiency as 80% and specific heat ratio as 1·4 for air, determine the specific fuel consumption (SFC) and brake mean effective pressure (BMEP). 25

5. *(a)* What are different methods of governing a steam turbine? Describe any two methods of governing a steam turbine. 12

(b) Dry and saturated steam enters a nozzle at an absolute pressure of 10 bars and with an initial velocity of 90 m/s. The outlet pressure is 6 bars and the outlet velocity is 435 m/s. The heat loss from the nozzle is 6·3 kJ/kg of steam flow. Calculate the dryness fraction and the area at the exit, area at the inlet is $12 \cdot 56\ cm^2$. 13

6. *(a)* Give the physical description of laminar and turbulent flows. How are they distinguished? Explain how the friction factor for laminar flow through smooth pipes and turbulent pipes flows are determined. Also sketch the Moody diagram and explain its uses. 10

(b) A Pelton wheel has a mean bucket speed of 10 m/s with a jet of water flowing at the rate of 700 litres/s under a head of 30 m. The buckets deflect the jet through an angle of 160°. Calculate the power given by water to the runner and the hydraulic efficiency of the turbine. Assume coefficient of velocity as 0·98. 15

7. Consider a 0·8 m high and 1·5 m wide glass window with a thickness of 8 mm and a thermal conductivity of 0·78 W/m-K. Determine the steady rate of heat transfer through this glass window and the temperature of its inner surface for a day during which the room is maintained at 20 °C while the temperature of outdoors is −10 °C. Assume the heat transfer coefficients on the inner and outer surfaces of the window to be 10 W/m^2-K and 40 W/m^2-K, which include the effects of radiation. 25

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SPACE FOR ROUGH WORK

SEAL