

SEAL

DO NOT OPEN THE SEAL UNTIL INSTRUCTED TO DO SO

Question Booklet No.

300415

Invigilator's signature

J/EE/R EXAM

2020

MECHANICAL ENGINEERING

Time : 2 Hours

Maximum Marks : 200

ROLL NO.

INSTRUCTIONS FOR CANDIDATES

1. This Test Booklet consists of two parts—PART-I (Objective) contains 50 multiple choice questions carrying 2 marks each and PART-II (Subjective) is of 100 marks.
2. In PART-I (Objective) each question contains four responses. Choose only one correct answer for each question and darken the bubble on the OMR RESPONSE SHEET. In PART-II (Subjective), answer all questions. The figures in the right-hand margin indicate full marks for the questions.
3. DO NOT write your Name or anything else except Roll No. and the actual answer to the question, anywhere on the OMR RESPONSE SHEET.
4. DO NOT handle your OMR RESPONSE SHEET in such a manner as to mutilate, fold, etc.
5. Entry into the examination venue shall be closed **10 minutes** before the scheduled commencement of the Examination, i.e. 8:50 AM for Forenoon session and 12:50 PM for the Afternoon session.
6. No candidate shall have in his/her possession, inside the Examination Hall, any book, notebook or loose paper, calculator, mobile phone etc., except his/her Admit Card and other things permitted by the Commission.
7. Immediately after the final bell indicating the closure of the Examination, stop bubbling. Be seated till the OMR RESPONSE SHEET is collected by the Invigilator. Thereafter you may leave the Examination Hall.
8. Violation of any of the above rules will render the candidate liable to expulsion from the examination and disqualification from the examination, and according to the nature and gravity of his/her offence, he/she may be debarred from future examinations and interviews to be conducted by the Commission and other such organizations (i.e. UPSC, SSC and SPSCs).

NB : CANDIDATES ARE ALLOWED TO TAKE THIS QUESTION BOOKLET ONLY AFTER COMPLETION OF 2 (TWO) HOURS EXAMINATION TIME

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PART—I
(Objective)

1. The unit of mass moment of inertia is
 - [A] $\text{kg}\cdot\text{m}^2$
 - [B] m^4
 - [C] kg/m^2
 - [D] kg/m

2. Two parallel and coplanar shafts are connected by
 - [A] spur gears
 - [B] bevel gears
 - [C] spiral gears
 - [D] helical gears

3. Module of a gear is
 - [A] the ratio of pitch circle diameter to the number of teeth
 - [B] the ratio of number of teeth to the pitch circle diameter
 - [C] the reciprocal of pitch circle diameter
 - [D] the product of pitch circle diameter and number of teeth

4. The working surface above the pitch surface of a gear tooth is termed as
 - [A] addendum
 - [B] dedendum
 - [C] flank
 - [D] face

5. The average tensions in the tight and slack side of a flat belt drive system are 700 N and 400 N respectively. If the linear velocity of the belt is 5 m/s, the power transmitted by the belt would be
 - [A] 1.5 kW
 - [B] 2 kW
 - [C] 2.7 kW
 - [D] 3.4 kW

6. Centrifugal tension in a belt drive
 - [A] reduces the speed of the driven wheel
 - [B] reduces friction between the belt and the pulley rim
 - [C] reduces the driving power of the belt
 - [D] increases the driving power of the belt

7. Weight percentage (%) of carbon in mild steels is
- [A] <0.008
 - [B] 0.008–0.30
 - [C] 0.3–0.8
 - [D] 0.8–2.11
8. Eutectic product in Fe-C system is called
- [A] pearlite
 - [B] bainite
 - [C] ledeburite
 - [D] spheroidite
9. Time-dependent yield is known as
- [A] fracture
 - [B] fatigue
 - [C] buckling
 - [D] creep
10. A draft tube is **not** required in a
- [A] Francis turbine
 - [B] Kaplan turbine
 - [C] Pelton wheel
 - [D] propeller turbine
11. A modern Francis turbine is
- [A] a radial flow-type reaction turbine
 - [B] an axial flow turbine
 - [C] a mixed flow-type turbine
 - [D] an impulse turbine
12. A Kaplan turbine is suitable for
- [A] low head and low discharge
 - [B] low head and high discharge
 - [C] high head and low discharge
 - [D] high head and high discharge
13. The operating characteristic curves of a turbine are obtained at constant
- [A] head and speed
 - [B] head and discharge
 - [C] speed and discharge
 - [D] load and speed
14. A surge tank is used in a pipeline to
- [A] reduce frictional loss in pipe
 - [B] ensure uniform flow in pipe
 - [C] reduce cavitation
 - [D] relieve excessive pressure caused by water hammer

15. Which of the following is **not** a positive displacement pump?
- [A] Reciprocating pump
 - [B] Centrifugal pump
 - [C] Vane pump
 - [D] Lobe pump
16. Discharge of a centrifugal pump is
- [A] directly proportional to speed
 - [B] inversely proportional to speed
 - [C] directly proportional to square of speed
 - [D] inversely proportional to square of speed
17. Overall efficiency of a centrifugal pump is the ratio of
- [A] energy available at the impeller to the energy supplied to the pump
 - [B] actual work done by the pump to the energy supplied to the pump
 - [C] energy supplied to the pump to the energy available at the impeller
 - [D] manometric head to the energy supplied by the impeller
18. In a reciprocating pump, air vessels are used to
- [A] reduce the flow
 - [B] increase the delivery head
 - [C] smoothen the flow
 - [D] reduce the acceleration head
19. The rise of oil through the wick of a lamp is due to
- [A] viscosity of oil
 - [B] adhesion between oil and wick material
 - [C] capillary action
 - [D] pressure difference between oil sump and the environment
20. Vapour pressure is a characteristic fluid property involved in the phenomenon of
- [A] water hammer in pipe
 - [B] cavitation
 - [C] spherical shape of falling rain drops
 - [D] break up of liquid jet

21. In flow through a pipe, the transition from laminar to turbulent **does not** depend on

- [A] velocity of the fluid
- [B] density of the fluid
- [C] diameter of the pipe
- [D] length of the pipe

22. The velocity distribution at any section of a pipe for steady laminar flow is

- [A] linear
- [B] exponential
- [C] parabolic
- [D] logarithmic

23. Manning's formula is used in open channel flow to determine

- [A] pressure
- [B] discharge
- [C] velocity
- [D] frictional head loss

24. In case of an immersed body, the resultant pressure of the liquid acts through

- [A] the centre of pressure
- [B] the centre of gravity
- [C] the metacentre
- [D] the centre of buoyancy

25. Which of the following is an extensive property of a thermodynamic system?

- [A] Volume
- [B] Pressure
- [C] Temperature
- [D] Density

26. In which of the following conditions, the change in enthalpy of a system equals the heat supplied?

- [A] Constant volume
- [B] Constant pressure
- [C] Constant temperature
- [D] Standard pressure and temperature

27. For which of the following processes, the value of the exponent n in the polytropic process $pv^n = C$ is $\pm\infty$?

[A] Throttling process

[B] Isochoric process

[C] Isentropic process

[D] Isobaric process

28. In a reversible isothermal process, a fluid expands from 10 bar and 2 m^3 to 2 bar and 10 m^3 . During this process, if 100 kW of heat is supplied, then the work done during the process is

[A] 33.3 kW

[B] 80 kW

[C] 100 kW

[D] 20 kW

29. The coefficient of performance (COP) of a refrigerator working on reversed Carnot cycle is 4. The ratio of the maximum to the minimum absolute temperature is

[A] 1.2

[B] 1.25

[C] 3.33

[D] 4

30. A heat pump working on a reversed Carnot cycle has a COP of 5. If it works as a refrigerator consuming 1 kW of energy, the refrigerating effect would be

[A] 1 kW

[B] 2 kW

[C] 3 kW

[D] 4 kW

31. For a thermodynamic cycle to be irreversible, it is necessary that

[A] $\oint \frac{\delta Q}{T} = 0$

[B] $\oint \frac{\delta Q}{T} < 0$

[C] $\oint \frac{\delta Q}{T} > 0$

[D] $\oint \frac{\delta Q}{T} \geq 0$

32. An engine operates between the temperature limits 900 K and T_2 and another engine operates between T_2 and 400 K. For the engines to be equally efficient, T_2 should be equal to

[A] 600 K

[B] 625 K

[C] 650 K

[D] 700 K

33. The capacity of a boiler is defined as

- [A] the amount of water evaporated into steam in one hour
- [B] the maximum pressure at which steam can be produced in a boiler
- [C] the volume of steam produced per hour
- [D] the maximum temperature at which steam can be produced in a boiler

34. Saturated liquid at a high pressure with an enthalpy of 1000 kJ/kg is throttled to a low pressure. At low pressure, the enthalpies of saturated liquid and saturated vapour are 800 kJ/kg and 2800 kJ/kg respectively. The dryness fraction of the vapour after the throttling process is

- [A] 0.9
- [B] 0.5
- [C] 0.8
- [D] 0.1

35. Which of the following fittings is mounted to put off fire in a boiler furnace when the water level falls below the desired level?

- [A] Feed check valve
- [B] Fusible plug
- [C] Safety valve
- [D] Blowdown valve

36. The reheat cycle in steam power plant is employed mainly to

- [A] improve thermal efficiency
- [B] recover waste heat from boiler
- [C] improve steam quality at turbine exit
- [D] reduce condenser heat loss in the plant

37. The term bleeding in a steam turbine refers to

- [A] leakage of steam from steam turbine
- [B] steam extraction for boiler feedwater preheating
- [C] removal of wet steam at low pressure stages of steam turbine
- [D] expansion of steam in various stages

38. In a back pressure turbine, the pressure of steam at turbine exhaust

- [A] is below atmospheric
- [B] is atmospheric
- [C] is above atmospheric
- [D] can be at any pressure

39. In a thermal power plant, deaerator is used to

- [A] remove air from condenser
- [B] increase feedwater temperature
- [C] reduce steam pressure
- [D] remove dissolved gases from feedwater

40. In a regenerative Rankine cycle, the steam extracted from the steam turbine is used to

- [A] preheat the combustion air
- [B] preheat the fuel
- [C] preheat the boiler feedwater
- [D] reheat the steam

41. A thermodynamic cycle consisting of two reversible adiabatic and two isobaric processes is known as

- [A] Otto cycle
- [B] Ericsson cycle
- [C] Joule cycle
- [D] Stirling cycle

42. In a power plant where the gas turbine exhaust is used to produce steam and subsequently drive a steam turbine is called a

- [A] topping cycle
- [B] bottoming cycle
- [C] cogeneration plant
- [D] combined cycle

43. In a gas turbine cycle, regenerator is used to

- [A] preheat the fuel supplied to the combustion chamber
- [B] preheat the compressed air supplied to the combustion chamber
- [C] preheat the gases leaving the combustion chamber
- [D] preheat the gases leaving the turbine

44. The process by which a heavy nucleus is splitted into smaller nuclei is called

- [A] fusion
- [B] fission
- [C] nucleation
- [D] chain reaction

45. The function of a moderator in a nuclear power plant is to

- [A] give protection from fast moving neutrons and gamma rays
- [B] absorb excess neutrons
- [C] slow down fast moving neutrons
- [D] send back the neutrons into the reactor core

46. Heavy water used in nuclear reactor serves as a

- [A] coolant
- [B] moderator
- [C] coolant and moderator
- [D] neutron absorber

47. The compression ratio of an IC engine is the ratio of

- [A] swept volume to clearance volume
- [B] total cylinder volume to swept volume
- [C] total cylinder volume to clearance volume
- [D] clearance volume to swept volume

48. Diesel engines are larger in size than petrol engine due to

- [A] use of diesel as engine fuel which is heavier than petrol
- [B] high compression ratio employed in diesel engine
- [C] use of comparatively more engine parts
- [D] use of larger combustion chamber

49. In an IC engine, the ratio of brake power to indicated power is called

- [A] volumetric efficiency
- [B] brake thermal efficiency
- [C] indicated thermal efficiency
- [D] mechanical efficiency

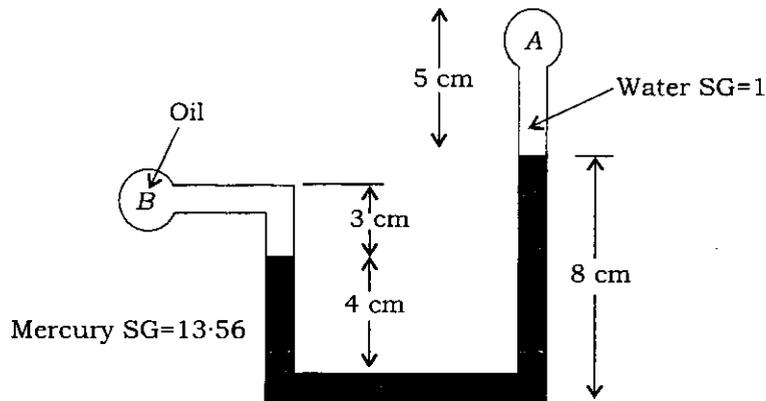
50. Specific fuel consumption of an engine is defined as

- [A] fuel consumed per km distance moved
- [B] fuel consumed during one hour of time
- [C] fuel consumption per kW of brake power per hour of time
- [D] fuel consumed in producing unit brake power

PART—II

(Subjective)

1. A rectangular plane surface 1 m wide and 1.5 m deep lies in water in such a way that its plane makes an angle of 30° with the free surface of water. Determine the total pressure and the position of centre of pressure when the upper edge is 2 m below the free water surface. 10
2. If the oil in the region shown in the figure, has a specific gravity (SG) of 0.8 and the absolute pressure of water at A is 1 atmosphere, what is the absolute pressure of oil at B? 10



Differential manometer with water in pipe A and oil in pipe B

3. An engine working on Otto cycle uses hexane as fuel. The engine works on chemically correct air fuel ratio and the compression ratio is 8. Pressure and temperature at the beginning of compression are 1 bar and 77°C respectively. If the calorific value of the fuel is 43000 kJ/kg and $C_p=0.717$ kJ/kg-K, find the maximum pressure and temperature of the cycle. Assume the compression follows the law $pV^{1.3}=C$. 10
4. In a gas turbine plant working on the Brayton cycle, the inlet air temperature and pressure are 27°C and 0.1 MPa respectively. The pressure ratio is 6.5 and the maximum temperature in the cycle is 800°C . The efficiency of the compressor and the turbine are each 80%. Find (a) the cycle efficiency and (b) the turbine exhaust temperature. 10
5. (a) A 10 cm thick steel plate has a thermal conductivity of 50 W/mK. The hot surface of the plate is maintained at 100°C . What will be the temperature of the cold surface of the plate if the applied heat flux on the hot side is 25 kW/m^2 ? 5

- (b) The hot side of above steel plate is now subjected to a heat flux of 800 W/m^2 . If the other side (cold side) transfers heat by convection to ambient air at 25°C , what will be the temperature on the other side of the plate if the heat transfer coefficient is $80 \text{ W/m}^2 \text{ K}$? 5
6. A water jet of 0.001 m^2 area leaves a nozzle with a velocity of 10 m/s . Determine the forces exerted by the water jet when it strikes (a) a stationary flat surface held normal to it and (b) a flat surface that moves away from the jet with a velocity of 2.5 m/s . 10
7. Explain with the help of schematics the working principles of vapour compression and vapour absorption refrigeration systems. State some major differences between the two. 8+2=10
8. In the Taylor's tool life equation, consider $n=0.5$ and $C=90$. If the cutting speed is reduced by 25%, what will be the percentage increase in tool life? Find also the change in tool life for 25% increase in cutting speed. 10
9. With the help of schematics, explain the differences between open and closed cycle gas turbine. What usual techniques are employed for increasing efficiency of gas turbine plants? 8+2=10
10. Name the types of water turbines used in hydel power plants. What is the basis of selection of water turbine for a given site? Give the detailed classifications. Write the difference between impulse and reaction turbine. 1+2+5+2=10