ARUNACHAL PRADESH PUBLIC SERVICE COMMISSION ITANAGAR

MECHANICAL ENGINEERING

Time: 3 hrs

Full marks: 200

Note: Answer question No 1 and any four from the remaining seven questions. All questions carry equal mark.

<u>Q. No. 1</u> - Attempt any 10 (ten) questions from the following: 10x4=40

A. What do you mean by the terms 'calorific value', 'upper calorific value' and 'lower calorific value, of fuels? Name an apparatus used for measuring CV of fuels.

- B. What is the velocity of a fluid leaving a nozzle, if the velocity of approach is very small?
- C. What is PMM2? Why is it impossible?
- **D.** The outer surface of a glass filled with iced water frequently sweats. Explain the cause of the sweating.
- **E.** Equipments made of brass have a tendency of getting cracked when worked with sea water. Explain why?
- **F.** What are the basic constituents of high speed steel? What are the common uses of high speed steel?
- G. State and explain Bernoulli equation. List the assumptions made during its formulation.
- H. How are methane based refrigerants denoted? Explain with two examples.
- I. What is Curie temperature? What is its value for iron and copper?
- J. What is a fusible plug and state where it is located in a boiler?
- K. Write the four symbols used for drawing process flow chart.
- L. What are cupolas? Give an outline of the construction of a cupola.

Q. No. 2 - Attempt any 8 (eight) questions from the following: 8x5=40

- A. Find the absolute pressure of a system in kPa when the pressure reading is 90 cmHg gauge and barometer reading is 760 mm of Hg.
- **B.** An engine of 100 kW capacity requires 15 kW to start the engine. Find its mechanical efficiency.
- C. A mild steel bar of section 20 mm x 40 mm and length 400 mm is subjected to an axial tensile load of 120 kN. If $E = 208 \text{ kN/mm}^2$, what will be the change in length of the bar?
- **D.** A force of magnitude 125 N has a component in x direction equal to 100 N. What is the component of force in y direction?
- E. The temperature of the freezer of a domestic refrigerator is maintained at -16° C whereas the ambient temperature is 35°C. If the heat leaks into the freezer at a continuous rate of 2 kJ/s, what is the minimum power required to pump out this heat leakage from freezer continuously?

- F. Steam expands in a turbine from its initial value 2 MPa, 300^oC (h= 3023.5 kJ/kg; s = 6.7663 kJ/kg.K) to a pressure for which the following values are applicable: h_f = 188.42 kJ/kg; h_{fg} = 2397.8 kJ/kg; s_f = 0.6386 kJ/kg.K; s_{fg} = 7.5261 kJ/kg.K. Find the work done by the turbine.
- G. The velocity distribution near the solid wall at a section in a laminar flow is given by $u = 5.0 \sin (5\pi y)$ for $y \le 0.10$ m. Compute the shear stress at a section at y = 0.05 m and y = 0.10 m. The dynamic viscosity of fluid is 5 poise.
- **H.** A cupola of 70 cm diameter has a melting of 10:1. How much iron is melted per hour, if the melting rate is 0.5 kg/hr/cm². How much coke is consumed per hour?
- I. Arrange the following metals in order of nobleness, i.e., from least noble to most noble: Cu, Pt, Pb, Sn, Zn, Cast Fe.
- J. For a nuclear power plant, find the correct answer for column A in column B:

2	Column A	Column B
	Graphite	Structural material
	Stainless steel	Control rod
	Sodium	Reflector
	Cadmium	Moderator
	Beryllium	Coolant in fast breeder reactors

Q. No 3 - Attempt any 5 (five) questions from the following:

5x8=40

- **A.** Explain the working principle of hot rolling. Name different products at different stages of rolling.
- **B.** What is the condition of isochronisms in governor? In what type of governor it can't be achieved? Find the required condition of isochronisms in case of a Hartnell governor?
- **C.** What do you measure with a pitot tube? What is the principle used in the measurement? Explain with a suitable diagram.
- **D.** Derive an expression for log mean temperature difference for a parallel flow heat exchanger.
- E. Name three boiler accessories. Why economizers are used in a boiler? What are the advantages of using an economizer?
- **F.** Draw the T-T-T diagram of eutectoid steel and show the important features. Indicate the microstructures of steel in terms of hardness.
- G. Define specific humidity and relative humidity. Explain how relative humidity is measured.

<u>Q. No. 4</u> - Attempt any 4 (four) questions from the following: 4x10=40

- A. For a particular product, the following information are given: Sale price = Rs. 10 per unit; Variable cost = Rs. 6 per unit; Fixed cost = Rs. 1 00 000.00. Due to inflation, the variable costs increased by 10%, while the fixed costs increased by 5%. If the break even quantity is to remain constant, by what percentage should the sale price be raised.
- **B.** A four-cylinder petrol engine has a bore of 57 mm and a stroke of 90 mm. Its rated speed is 2800 rev/min and it is tested at this speed against a brake which has a torque arm of 0.356 m. The net brake load is 155 N and the fuel consumption is 5.74 l/hr. The specific

gravity of the petrol used is 0.735 and it has a lower calorific value of 44 200 kJ/kg. A Morse test is carried out and the cylinders are cut out in the order 1, 2, 3, 4 with corresponding brake loads of 111, 106.5, 104.2 and 111 N respectively. Calculate for this speed, the engine torque, the bmep, the brake thermal efficiency, the specific fuel consumption, and the mechanical efficiency.

- C. The turning moment diagram for a petrol engine is drawn to a vertical scale of 1 mm = 500 Nm and a horizontal scale of 1 mm = 3^{0} . The turning moment diagram repeats itself after every half revolution of the crankshaft. The areas above and below the mean torque line are 260, -580, 80, -380, 870, and -250 mm². The rotating parts have a mass of 55 kg and radius of gyration of 2.1 m. If the engine speed is 1600 rpm, determine the co-efficient of fluctuation of speed.
- **D.** A simply supported beam of square cross-section 5 mm x 5 mm and length 1 m, carrying a mass of 2.3 kg at the middle, is found to have a natural frequency of transverse vibration of 30 rad/s. Determine the Young's modulus of elasticity of the beam.
- **E.** Air enters the compressor of gas turbine plant at 1 bar and 30^oC and compressed to 6 bar with an isentropic efficiency of 85%. The turbine inlet temperature is 500^oC. The isentropic efficiency of the turbine is 80%. Estimate the air flow in kg/s for net power output of 1470kW. Neglect the amount of fuel.

<u>Q. No. 5</u> - Attempt any 2 (Two) questions from the following: 2x20=40

- A. What is annealing? Explain how the structure and properties of a cold worked low carbon steel change as it is heated gradually in the annealing range.
- **B.** Using the method of dimensional analysis, establish the relationship between Nusselt number, Grashoff number and Prandtl number for a natural convection heat transfer process.
- **C.** What are the methods employed to increase the thermal efficiency of a Brayton cycle? Explain with simple diagrams.

Q. No.6 - Draw the vapour compression refrigeration plant-flow diagram, its T-s, p-v, h-s and p-h diagrams to show all the processes involved in the cycle. Explain the processes and obtain mathematical relationships for the refrigerating effect and the COP of the refrigerator. Show the effect of irreversibility on the cycle. 10+10+8+6+6=40

Q. No.7 - Define specific speed of a turbine. Derive an expression for the specific speed of a hydraulic turbine. What is the significance of the specific speed?

A Kaplan turbine develops 20 MW when running at 130 rpm under a head of 20 m. The outer diameter of the runner is 4 m and the hub diameter is 1.8 m. The hydraulic and overall efficiency of the turbine are 90% and 85% respectively. Determine the discharge through the turbine and the blade angles at inlet and outlet measured at the mean radius of the runner.

5+10+5+20=40

Q. No.8 - What is knock in internal combustion engines? Explain how it occurs in SI engines. How does it differ from knock in diesel engines? What are the properties desired of fuels for SI engines to avoid knock? **10+10+10=40**

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