**BITS, PILANI-DUBAI**
**SECOND SEMESTER 2007-2008**
# ME UC332 PRIME MOVERS AND FLUID MACHINES
**Comprehensive Exam DATE: 21-05-08**

**DURATION: 3hrs MAXIMUM MARKS: 35 WEIGHTAGE: 35%**

***Notes: Thermodynamic tables are allowed.***
***Highlight all your answers by enclosing in boxes. Assume any missing data suitably and mention the same at the appropriate place in your answer. All the parts of the same question should be answered together.***

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1 Derive an expression for the thrust developed by a propeller which depends upon the angular velocity $\omega$, approach velocity V, dynamic viscosity $\mu$, density $\rho$, propeller diameter D and the compressibility of the medium measured by the local velocity of sound C. **4**

2. Single jet Pelton turbine is required to drive a generator to develop 10MW. The available head at the nozzle is 760m.Assuming electrical generator efficiency of 95%, Pelton wheel efficiency of 87%, coefficient of velocity for the nozzle 0.97, mean bucket velocity 0.46 of jet velocity, outlet angle of the buckets is 15° and the blade velocity coefficient (K) as 0.85 of the inlet find a. the diameter of the jet, b. the flow rate of water, and c. the force exerted by the jet on the buckets. **5**

3 A single acting reciprocating pump has a plunger diameter of 200mm and a stroke of 300mm.The suction pipe is 100mm in diameter and 8m long. The water surface in the sump from which the pump draws water is 4m below the pump cylinder axis. If the pump is working at 30 rpm find the pressure head on the piston at the beginning, middle and end of the suction stroke. Take f=0.01 and Hatm = 10m of water. **6**

4. A four-stage single acting air compressor delivers 1.5 $m^3$ of free air per min at 100 bar. The ambient conditions are 1.03 bar and 20 °C. The suction conditions are 0.98 bar and 30 °C. Assuming perfect intercooling find the indicated power of the compressor. If the clearance is the 4% of the stroke in all cylinders and common stroke is equivalent to the diameter of he lowest pressure cylinder find the diameters and strokes of all the cylinders. Take the index of compression and re expansion is 1.32 and speed of the compressor as 300 rpm. Neglect the pressure losses between the stages. **6**

**5.** Derive an expression for maximum discharge and maximum velocity through a steam nozzle in terms of expansion index n and inlet conditions. **4**

**6.** Determine the condition for maximum efficiency of a 50% reaction turbine and show that the maximum efficiency for such a turbine is $[2\text{Cos}^2\alpha 1 / (1+ \text{Cos}^2\alpha 1)]$, where $\alpha 1$ is the angle at which the steam enters the blades. **5**

**7.** Air at a temperature of 17°C flows in to the centrifugal compressor running at 20000rpm. Using the following data slip factor=0.8,work input factor=1, isentropic efficiency =70%, outer diameter of blade tip =50cm. assuming the absolute velocities of air entering and leaving the compressor are same find the temperature rise of air passing through compressors and the static pressure ratio. Take Cp for air =1 kJ/.kg-K and $\gamma$ for air=1.4 **5**

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# TEST 2(Open book)

**DATE: 10-04-08**

**DURATION: 50 MINUTES MAXIMUM MARKS: 15 WEIGHTAGE: 15%**

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1. Differentiate between single acting & double acting and single throw & multi throw reciprocating pumps. Explain what a duplex pump is.

2. A single acting single cylinder reciprocating pump of 325mm diameter and 400 mm stroke has suction and delivery pipes 15cm in diameter. Their lengths are 6m and 70m respectively. The suction and delivery heads are 4.5m and 50m respectively. Calculate the minimum absolute pressure of the pump at two instants during suction and delivery and based on that calculate the maximum permissible speed of the pump in order to avoid separation. Take atmospheric pressure = 10.3 m of water and vapor pressure = 2.2 m of water. **3**

3. A centrifugal pump delivers 300 liters/sec of water at a head of 20m. The blades are radial at outlet and the velocity of flow is constant throughout and is equal to 3m/sec. Estimate the leading dimensions of the impeller (diameter &width at inlet and outlet) if diameter at inlet is half the diameter at outlet and manometric efficiency is 80%. Take the speed of the pump as 1000 rpm and the vane angle at outlet as 30°. **4.5**

4. Steam at 20 bar and 250°C expands isentropically to a pressure of 3 bar in a convergent – divergent nozzle. Calculate the mass flow per unit area
   a. assuming equilibrium flow and
   b. assuming super saturated flow.

   For super saturated flow assume that the process follows the law $PV^{1.3}=C$.

5. What is the need for compounding the steam turbines? State the different methods of compounding and name one practical turbine working on this principle. **1.5**

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# TEST 1

**DATE: 24-02-08**

**DURATION: 50 MINUTES MAXIMUM MARKS: 15 WEIGHTAGE: 15%**

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1 The pressure drop when a fluid is flowing in a pipe line is dependent on the following parameters. The tube length l, hydraulic diameter d, the average height of the bumps on the surface measured in micrometres ε, fluid density ρ and viscosity μ and the average velocity v of the fluid. Using the principle of dimensional analysis and π theorem establish a functional relation between the parameters. **4**

2. Define, give expression and explain the significance of the following non dimensional numbers.

a. Reynolds number and b. Mach number. **3**

3. A one sixth scale turbine model is tested under a head of 40m. The full scale turbine is required work under a head of 150m and to rotate at 600rpm. Estimate the speed of the model if it produces 150 kW when the discharge is 0.75 $m^3$/sec and also the power produced by the prototype if its efficiency is 5% more than the model. **4**

4. With inlet and outlet velocity triangles of a Pelton wheel runner blade derive an expression for the hydraulic efficiency. Find the condition for the maximum efficiency and prove that the max efficiency is $(1+k\cos\beta)/2$. **4**

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