9. *(a)* What are centrifugal compressors? With the help of velocity diagram, deduce the expression of work done and pressure rise in centrifugal compressor. 7

(b) A centrifugal compressor runs at a speed of 15000 r.p.m. and delivers 30 kg of air per second. Exit radius is 0·35 m, relative velocity at exit is 100 m/s at an exit angle of 75°. Assume axial inlet and $T_{01} = 300$ K and $P_{01} = 1$ bar. Calculate *(i)* the torque, *(ii)* the power required to drive the compressor, *(iii)* the ideal head developed *(iv)* the work done and *(v)* the exit total pressure. 7

★ ★ ★

B.Tech 5th Semester Exam., 2018

FLUID MACHINERY

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

(ii) There are ***NINE*** *questions in this paper.*

(iii) Attempt ***FIVE*** *questions in all.*

(iv) Question No. ***1*** *is compulsory.*

1. Choose the correct answer from the following (any *seven*) : 2×7=14

(a) The force of impingement of a jet on a vane increases, if

(i) the vane angle is increased

(ii) the vane angle is decreased

(iii) the pressure is reduced

(iv) the vane is moved against the jet

(b) A jet of water issues from a nozzle with a velocity of 20 m/s and it impinges normally on a flat plate moving away from it at 10 m/s. If the cross-sectional area of the jet is 0·02 m^2 and the density of water is taken as 1000 kg/m^2, then the force developed on the plate will be

(i) 10 N

(ii) 100 N

(iii) 1000 N

(iv) 2000 N

(c) Kaplan turbine is

(i) a high head mixed flow turbine

(ii) a low axial flow turbine

(iii) an outward flow reaction turbine

(iv) an impulse inward flow turbine

(d) Cavitation in a hydraulic turbine is most likely to occur at the turbine

(i) entry

(ii) exit

(iii) stator exit

(iv) rotor exit

(e) Euler equation for water turbine is derived on the basis of

(i) conservation of mass

(ii) rate of change of linear momentum

(iii) rate of change of angular momentum

(iv) rate of change of velocity

(f) A Francis turbine is coupled to an alternator to generate electricity with a frequency of 50 Hz. If the alternator has 12 poles, then the turbine should be regulated to run at which one of the following constant speeds?

(i) 250 r.p.m.

(ii) 500 r.p.m.

(iii) 600 r.p.m.

(iv) 1000 r.p.m.

(g) Consider the following types of water turbines :

1. Bulb, 2. Francis, 3. Kaplan,

4. Pelton

One correct sequence of order in which the operating head decreases while developing the same power is

(i) 4–2–3–1

(ii) 3–4–1–2

(iii) 2–1–4–3

(iv) 1–3–2–4

(h) When the speed of a centrifugal pump is doubled, the power required to drive the pump will

(i) increase 8 times

(ii) increase 4 times

(iii) double

(iv) remain the same

(i) A centrifugal pump driven by a directly coupled 3 kW motor of 1450 r.p.m. speed is proposed to be connected to another motor of 2900 r.p.m. speed. The power of the motor should be

(i) 6 kW

(ii) 12 kW

(iii) 18 kW

(iv) 24 kW

(j) Air vessel is used in a reciprocating pump to obtain

(i) reduction of suction heat

(ii) rise in delivery head

(iii) continuous supply of water at uniform rate

(iv) increase in supply of water

2. (a) Differentiate between impact of jet and jet propulsion. Show that the force exerted by a jet of water on moving inclined plate in the direction of jet is given by

$$F_x = \rho a (V-u)^2 \sin^2 \theta$$

where a is area of jet, V is velocity of jet and θ is inclination of the plate with the jet. 7

(b) A 75 mm diameter jet having a velocity of 30 m/s strikes a flat plate, the normal of which is inclined at 45° to the axis of the jet. Find the normal pressure on the plate when the plate is stationary, when the plate is moving with a velocity of 15 m/s in the direction of jet, away from the jet and also determine the efficiency of the jet when the plate is moving. 7

3. (a) Derive Euler's equation of motion. Also derive Bernoulli's equation with the help of Euler's equation. 7

(b) A pipe 200 m long slopes down at 1 in 100 and tapers from 600 mm diameter at the higher end to 300 mm diameter at the lower end, and carries 100 litres/s of oil (specific gravity 0·8). If the pressure gauge at the higher end reads 60 kN/m^2, calculate velocities at the two ends and pressure at the lower end neglecting all the losses. 7

4. (a) What is a hydraulic turbine? How are they classified? With the help of neat sketch, explain the construction and working of a Pelton wheel turbine. 7

(b) An inward flow reaction turbine has external and internal diameters as 1 m and 0·5 m respectively. The turbine is running at 200 r.p.m. and width of turbine at inlet is 200 mm. The velocity of flow through the runner is constant and is equal to 1·8 m/s. The guide blades make an angle of 10° to the tangent of the wheel and the discharge at the outlet of the turbine is radial. Calculate all velocity vectors and draw the inlet and outlet velocity triangles. Also calculate mass flow through the runner/second, power developed and hydraulic efficiency. 7

5. *(a)* What is model analysis? What are the advantages and applications of model testing? 7

(b) A 1:8 model of a 12 ft diameter turbine is operated at 600 r.p.m. under a net head of 54·0 ft. Under this mode of operation, the bhp and Q of the model were observed, to be 332 hp and 62 cfs, respectively. From the above data, compute *(i)* the specific speed of the model and the value of φ, *(ii)* the efficiency and shaft torque of the model, *(iii)* the efficiency of the prototype, *(iv)* the flow rate and horsepower of the prototype if it is operated at 450 r.p.m. under a net head of 200 ft. 7

6. *(a)* What is negative slip in a reciprocating pump? Explain with neat sketches the functions of air vessels in a reciprocating pump. 7

(b) The diameter and stroke length of a single-acting reciprocating pump are 75 mm and 150 mm respectively. It takes its supply of water from a sump 3 m below the pump through a pipe 5 m long and 40 mm in diameter. It delivers water to a tank 12 m above the pump through a pipe 30 mm in diameter and 15 m long. If separation occurs 75 kN/m^2 below the atmospheric pressure, find the maximum speed at which pump may be operated without separation. Assume that the piston has a simple harmonic motion. 7

7. *(a)* With the help of neat sketch, discuss various components and working of a volute type centrifugal pump. 7

(b) A centrifugal pump is running at 1000 r.p.m. The outlet vane angle of the impeller is 300 and the velocity of flow at outlet is 3 m/s. The pump is working against a total head of 30 m and the discharge through the pump is 0·3 m^3/s. If the manometric efficiency of the pump is 75%, determine *(i)* the diameter of the impeller and *(ii)* width of the impeller at the outlet. 7

8. *(a)* What are reciprocating compressor? Calculate the isothermal and adiabatic work and efficiency of a single-stage reciprocating compressor. 7

(b) A two-stage single reciprocating compressor takes in air at the rate of 2 m^3/s. The intake temperature and pressure of air are 0·1 MPa and 16° C. The air is compressed to a final pressure of 0·7 MPa. The intermediate pressure is ideal and cooling is perfect. The compression index in both the stages is 1·25 and the compressor runs at 600 r.p.m. Neglect clearance. Determine intermediate pressure, total volume of each cylinder, power required to drive the compressor and rate of heat rejection in the intercooler. 7