MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 400: FLUID MECHANICS IV

DATE: 16/8/2021 **TIME: 2.00-4.00 PM**

INSTRUCTIONS

Answer question ONE and any other two questions.

QUESTIONS ONE (COMPULSORY) (30 MARKS)

a) i. Diagrammatically show a typical circuit for hydraulically operated machining incorporating, intensifier and a hydraulic crane (7 marks)

ii. Explain their functions and modes of operation. (7 marks)

b) i. What is a "Fluid coupling"? (3 marks)

ii. Using a clearly labelled diagram describe the structure and mode of operation of a 'fluid coupling'. (8 marks)

iii Derive an expression for the efficiency of a fluid coupling (3 marks)

iv State two advantages of using Fluid Couplings (2 marks)

QUESTIONS TWO (20 MARKS)

a) Show that the maximum hydraulic efficiency of a Pelton wheel η_{max} is given by;

$\eta_{max} = \frac{1}{2}[1 - k\cos\theta]\ x\ 100\%$ (12 marks)

Where; $k = \frac{Relative\ velocity\ of\ water\ at\ exit}{Relative\ velocity\ of\ water\ at\ inlet}$

$\theta = Angle\ through\ which\ the\ jet\ is\ deflected$

b) The diameter of a Pelton Wheel disc is 0.9 m and the deflecting angles of the buckets is 160^0. The jet is 75 mm in diameter. The speed of the wheel is 300 rpm and the pressure in the nozzle 690 kN/m^2.

Neglecting friction, determine the;

i. Power developed by the wheel (4 marks)

ii. Hydraulic efficiency (4 marks)

QUESTIONS THREE (20 MARKS)

a) Concisely describe the mode of operation of a reciprocating pump. (2 marks)

b) Define the following terms with respect to reciprocating pumps;

i. Volumetric efficiency (2 marks)

ii. Slip (2 marks)

c) Using clearly labelled diagrams, describe the structure and mode of operation of a double acting single cylinder reciprocating pump. (marks)

d) i. Distinguish between a suction and force reciprocating pumps (2 marks)

ii. Derive the expression for the accelerating supply head for a single acting single cylinder force pump; (6 marks)

$$H_S = \frac{l_s}{g}\frac{A_p}{a_s}\omega^2 r\cos\omega t$$

Where; l_s= length of the supply pipe in m

A_p = cross sectional area of the piston m^2

g = acceleration due to gravity (m/s^2)

a_s = cross sectional areas of the supply pipe m^2

ω = rotational speed in rads/s

r = crank (m)

iii. A single-acting, single cylinder reciprocating pump has a plunger diameter of 125 mm and a stroke of 300 mm. The length of the suction pipe is 10 m and the diameter 75 mm. Find the acceleration head at the beginning of the stroke when the pump is running at 30 rpm. If the height of the pumps centre is 3 m above the water level in the sump, determine the accelerating pressure head in the cylinder at the beginning of the stroke. (6 marks)

QUESTION FOUR (20 MARKS)

a) Describe the physical arrangements and mode of operation using a well labelled schematic diagram, of a centrifugal pump plant and delivery pipes (6 marks)

b) Define the following terms with reference to centrifugal pumps;

i. Manometric efficiency (1 mark)

ii. Mechanical efficiency (1 mark)

iii. Overall efficiency (1 mark)

c) A centrifugal pump has a total lift of 15 m from the well to the delivery tank. The wheel is 1.5 m above the well water surface. The velocity of delivery from the uptake is 1.5 m/s, the radial velocity of flow through the wheel is 3 m/s; the tangent to the vane at exit from the wheel makes an angle of 120^0 with the direction of motion, the water enters the wheel radially.

Find

i. Velocity of the wheel at exit from the wheel (2 marks)

ii. Pressure head at exit from the wheel (2 marks)

iii. Velocity head of water at exit from the wheel (3 marks)

iv. Angle of inclination of fixed vanes (4 marks)

QUESTION FIVE (20 MARKS)

a) Define the term 'specific speed' of a turbine (2 marks)

b) Show that the Specific speed of a turbine (Ns) is given by; (6 marks)

$N_S = \frac{NP^{1/2}}{H^{5/4}}$

Where;

N = Speed of the turbine

P = Output power

H = Head

c) An inward flow reaction turbine receives at 0.60 m^3/s under a head of 18 m while developing 89 kW of power. The internal and external diameters of the wheel are 0.50 m and 0.75 m respectively. The rotational velocity of the turbine is 375 rpm and the exit velocity is 3.5 m/s and in radial. Assume flow widths at outer and inner end are equal. Determine;

i. overall efficiency (3 marks)

ii. Hydraulic efficiency (3 marks)

iii. Inlet angles of guide blades (3 marks)

iv. Inlet angles of runner blades (3 marks)