KATHMANDU UNIVERSITY
End Semester Examination
July/August, 2024

Marks Scored:

Level : B.E.
Year : III

Course : MEEG 309
Semester : II

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date : 30 JUL 2024

SECTION "A"

[20 Q. × 1 = 20 marks]

Choose and mark [X] in the most appropriate option from each set of choices

1. In a centrifugal pump, cavitation is reduced by:
   [ ] increasing the flow velocity [ ] reducing the suction head
   [ ] increasing the suction head [ ] reducing the discharge

2. How does a pump performance curve change if the pump speed is increased?
   [ ] the curve shifts upwards [ ] the curve shifts downwards
   [ ] the curve becomes steeper [ ] the curve becomes shallower

3. On a pump performance curve, what does the term "shut-off head" refer to?
   [ ] the maximum flow rate the pump can handle
   [ ] the point where the pump stops operating
   [ ] the head developed by the pump when no flow is passing through
   [ ] the minimum head required the pump to start operating

4. Which type of draft tube is commonly used in high-head turbine installations?
   [ ] Simple draft tube [ ] Elbow draft tube
   [ ] Conical draft tube [ ] Bell-mouth draft tube

5. Which of the following best describes the principle behind the impact of jets?
   [ ] conservation of energy [ ] conservation of momentum
   [ ] conservation of mass [ ] conservation of angular momentum

6. Which parameter has the most significant impact on the efficiency of a Pelton turbine?
   [ ] nozzle diameter [ ] bucket shape [ ] water flow rate [ ] runner material

7. What is the purpose of the stay vanes in a Francis turbine?
   [ ] increase turbine efficiency [ ] regulate water flow
   [ ] prevent cavitation [ ] control the direction of water flow

8. What is the primary disadvantage of Kaplan/Propeller turbines compared to other types?
   [ ] limited to high-head applications [ ] lower efficiency
   [ ] complexity of design [ ] higher maintenance requirements

9. A centrifugal pump is installed at a height of 5 m above the sump water level. Frictional losses in the suction side of the pump amount to 0.6 m. The atmospheric pressure is 10.3 m of water and the vapour pressure is 0.4 (abs). The NPSHA of the pump is
   [ ] 3.7 m [ ] 4 m [ ] 4.3 m [ ] 4.6 m

10. If in a pump the discharge is halved while keeping the speed unchanged, the ratio of new head H_2 to old head H_1 is
[ ] $(1/2)^2$ [ ] $(1/2)^{3/2}$ [ ] $(1/4)$ [ ] $(1/2)^{1/3}$

11. A hydro project has a potential of 90 MW to be developed under a head of 350 m. A speed of 300 rpm is preferred. Which of the following combinations of Pelton turbines that can be used in this project.
[ ] 6 units of 2 jets [ ] 5 units of 3 jets [ ] 4 units of 4 jets [ ] 3 units of 5 jets

12. It is required to pump 1.3 m^3/s of water to a total head of 45 m. How many pumps of specific speed 40 and running at 1450 rpm would be needed when connecting in parallel, when the dynamic head in the system can be neglected?
[ ] 3 [ ] 4 [ ] 5 [ ] 6

13. At a site on a river, the power potential is 225 MW under a net head of 15 m. It is desired to operate the turbines at a speed of 60 rpm. Two choices of turbines, as follows are available: (a) Francis turbine having specific speed not exceeding 300 (b) Kaplan turbine having specific speed not exceeding 600. How many units of each type (Francis and Kaplan), all of same size, would be required?
[ ] 10 and 4 units [ ] 11 and 3 units [ ] 12 and 2 units [ ] 9 and 5 units

14. The slow, medium and fast runners of Francis turbines are specified by_____
[ ] β_1 [ ] α_1 [ ] β_2 [ ] α_2

15. If the buckets of Pelton turbine are semi-circular, theoretically, the jet is deflected through 180° and therefor, the blade angle at exit is_____
[ ] 0° [ ] 45° [ ] 90° [ ] 180°

16. If the rotational speed is high than for the same power then it
[ ] involves deeper excavation to overcome cavitation problem
[ ] does not involve additional excavation to overcome cavitation problem
[ ] requires a bigger size of the hydraulic turbine
[ ] units will occupy large space

17. The range of speed ratio of Kaplan turbine is _____
[ ] 0.45 - 0.48 [ ] 0.72 - 0.82 [ ] 1.3 -2.3 [ ] 2.5 -3.0

18. The range of diameter of Pelton turbine is _____
[ ] 1.5 - 5 m [ ] 1 - 10 m [ ] 2 - 8 m [ ] 3.5 - 7 m

19. The power curve for pump shall not pass through the origin _____
[ ] to overcome mechanical losses [ ] to overcome cavitation problems
[ ] to obtain the maximum efficiency [ ] all of the above

20. Which parameter is typically held constant to obtain the characteristics curves of hydraulic turbines?
[ ] speed [ ] head [ ] efficiency [ ] all of the above

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July/August, 2024

30 JUL 2024

Level : B.E.
Year : III
Time : 2 hrs. 30mins.

Course : MEEG 309
Semester : II
F. M. : 55

SECTION "B"
[5 Q. × 11 = 55 marks]

Attempt *ALL* questions. *Formula sheet is supplied in this exam along with the question. Assume suitable data if missing/necessary.*

1.

a. How does power output and torque on the shaft of a Pelton wheel vary with bucket speed? [3]
b. Briefly explain inlet and outlet velocity triangle of Pelton turbine. How is the ideal hydraulic efficiency of a Pelton turbine 100 %? [3]
c. A 7.5 cm diameter jet having a velocity 30 m/s strikes a flat plate, the normal of which is inclined at 45^0 to the axis of the jet. Find the normal force exerted on the plate. (i) When plate is stationary, (ii) When the plate is moving with a velocity of 15 m/s in the direction of jet away from the jet. Also determine the power and efficiency of system in both cases. [5]

2.

a. Discuss the consequences for selecting higher rotational speed for the same power? [2]
b. Define specific speed of a turbine and derive an expression for the same. Show that Pelton turbine is a low specific speed turbine. [3]
c. At a particular hydropower plant, water available under a head of 250 m is delivered to the powerhouse through there pipes each 2500 m long. Through these pipes, friction loss is estimated to be 20 m. The project is required to produce a total of 13.25 MW by installing a number of single jet Pelton wheels whose specific speed is not to exceed 38.5. The other pertinent data is: wheel speed = 650 rpm, ratio of bucket to jet speed = 0.46, overall efficiency of the wheel = 85%, $C_D = 0.94$ and flow coefficient = 0.97. Pipe coefficient f = 0.005 in the formula, $hf = \frac{4flV^2}{2gD}$. Determine: (i) the number of Pelton wheel to be used (ii) the jet diameter and (iii) diameter of supply pipes. [6]

3.

a. Write a note on the governing mechanism of a Kaplan turbine. [3]
b. Describe the importance of draft tubes in Kaplan turbine. [3]
c. A centrifugal pump rotating at 1000 rpm delivers 160 l/s of water against a head of 30 m. The pump is installed at a place where atmospheric pressure is $1x10^5$ Pa (abs.) and vapor pressure of water is 3 kPa (abs.). The head loss in suction pipe is equivalent to 0.2 m of water. Calculate: (i) minimum NPSH, and (ii) maximum allowable height of the pump from free surface of water in the sump. [5]

P.T.O.

4.

a. Compare and contrast the salient features of a Francis turbine and a Kaplan turbine. [2]
b. Draw a neat sketch of velocity triangles at inlet and outlet of a Propeller turbine blade at the following locations: (a) tip of blade, (b) hub of blade, and (c) mid radius location. [3]
c. For given flow rate = 71.5 m^3/s, and head = 543 m, design the main dimensions of Francis turbine. How do you assure that your design is free from cavitation problem? [6]

5.

a. State how the change in speed and diameter of impeller affects the discharge, head and power of a centrifugal pump. [3]
b. Explain the terms manometric efficiency, mechanical efficiency and overall efficiency as applied to centrifugal pumps. [3]
c. What are the main dimensions of a Kaplan turbine? Design the main dimensions of a Kaplan turbine for head: 16 m, flow rate: 120 m^3/s, and sped = 125 rpm. [5]