Indian Institute of Technology, Delhi
Centre for Energy Studies
2016-2017

ESL 740: NON-CONVENTIONAL SOURCES OF ENERGY

Minor Examinations — Marks: 20
Duration: 60 minutes. — 27 Aug. 2016

***Note:** Any assumptions made must be clearly mentioned and detailed steps need to be shown in derivations, for marks to be given*

Section-A

Answer all questions

1. Explain in brief the following phrases:
   a. *Biofouling* in an OTEC plant
   b. *Sophisticated method* in flow measurement in small hydro systems.

   [1.5 × 2=3]

2. State True or False. If False, give the correct answer or else marks will not be given.
   a. The operational efficiency of the Pelton wheel is higher than the Banki wheel based turbine.
   b. The fetch of the surface wave in an open sea is equal to the wavelength of the wave that is propagating on the surface. **[2]**

3. Take the help of diagrammatical methods and show that the slope of the tangent to the water surface wave, propagating along the surface in the x-direction, is given by:

$$\frac{dh}{dx} = \frac{a\omega^2 \sin\left[\frac{\pi}{2} - \omega t\right]}{g}$$

   where, a is the amplitude of the wave, ω is the angular velocity of the water particles, g is the acceleration due to gravity, h is the height of the water surface above mean level. **[4]**

4. State the difference between:
   a. Diurnal and semi-diurnal tides
   b. Swell and fetch of a wave **[1.5×2=3]**

Section-B

Answer any *one* of the following questions

5. In a hot-water aquifier system covering an area A
   a. Give a simplified analysis for geothermal heat extraction, stating any assumptions made and thereby derive an expression for the
      i. Total useful energy content per unit area in the aquifier at depth z_2 with width h and porosity p

ii. Rate of useful heat extraction

b. The surface temperature near such a system is 20°C with the aquifier, having a thickness 1 km and porosity 10%, located at a depth of 6 km from the surface under sediments of density 2.7 gm/cm^3, specific heat capacity 840 J/kg-K and a temperature gradient of 40°C/km. Given that the density of water is 1 gm/cm^3 and the specific heat capacity of water is 4.2 kJ/kg-K, estimate the total heat content in the hot acquifier region and the rate of volume of water flow such that the rate of useful heat extraction per unit area reduces from 28 MW/km^2 to 22 MW/km^2 in 10 years. **[4+2+2=8]**

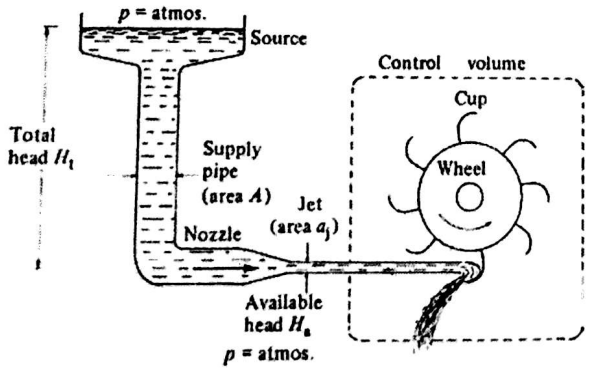
6. In a small hydro system, a Pelton wheel cup is so shaped that the exit flow makes an angle θ with the incident jet, as seen in the cup frame. As in Figure below, u_j is the jet velocity incident on the cup and u_c is the tangential velocity of the cup, measured in the laboratory frame. Show that if the energy lost by friction between the water and the cup is be measured by a loss coefficient k then

$$u_{r1}^2 = u_{r2}^2(1+k)$$

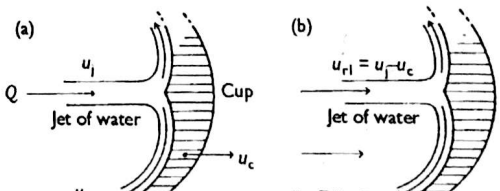
Further show that the power transferred is:

$$P = Q\rho u_c(u_j - u_c)\left[1 + \frac{\cos\theta}{\sqrt{(1+k)}}\right]$$

where, Q is the flow rate of water in the penstock and ρ is the density of water. Derive the mechanical efficiency η_m. What is the reduction in efficiency from the ideal when $\theta = 7°$, $k = 0.1$? Derive any other relations used.



Schematic diagram of a Pelton wheel impulse turbine.



Speed of cup and fluid, in (a) the laboratory frame (b) the frame of the cup.

[3+2+2+1=8]

Given the following constants:

Density of granite = 2.7 gm/cm^3

Density of water = 1 gm/cm^3

Specific heat capacity of granite = 840 J kg^{-1}K^{-1}

Specific heat capacity of water = 4.2 kJ kg^{-1}K^{-1}

1m^3 = 1000 liters