THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION FOR THE DEGREE OF B.E.

4813 HEAT TRANSFER AND POWER TRANSMISSION
6790 MECHANICAL DESIGN AND HEAT TRANSFER

NOVEMBER, 1999

TIME: 3 HOURS

[In addition, candidates are allowed ten minutes before the exam begins, to read the paper.]

[The use of notes, textbooks and calculating devices is permitted in the examination room.]

Attempt **ALL FIVE** questions

---

1. For each of the following devices, specify the Service Factors. Give brief justification of your reasoning.
   (a) A wood saw powered by a single cylinder diesel engine, connected by a flat rubber belt.
   (b) A wood saw powered by an electric motor, connected by a V-belt.
   (c) An air compressor powered by an electric motor, connected by a V-belt.
   (d) A mobile rock crusher used in road construction powered by an 8 cylinder engine, connected b y a chain.
   (e) A grass slasher, powered by the hydraulic power take-off of a 4 cylinder diesel tractor, connected by a V-belt.

   [15 Marks]

2. A single cylinder industrial diesel engine develops its maximum torque at 2000 r.p.m. when its output is 14.1 kW. The engine is used to drive a hoist through a single plate clutch of the type shown in the diagram. If the mean diameter of the friction surfaces is 152mm, the coefficient of friction is 0.60 and the maximum allowable pressure is 0.20 MPa for the friction material, calculate the inner and outer diameters of the clutch facings and the minimum spring force required to apply the pressure. Allow a design margin of 50% on the torque rating of the clutch with the surfaces 'bedded in'.

   [20 Marks]

PLEASE SEE NEXT PAGE

3. Recent attempts to circle the globe in a balloon have raised issues about heat transfer from the gondola. The following case is to be analysed: a cylindrical balloon gondola with a 2.4 m diameter and a length of 4 m rises to an altitude where the ambient pressure is 1.3kPa and the ambient temperature is -52°C. The outside surface of the sphere is at approximately 0°C.

a) explain the difference between free and forced convection. What role does the density of the air play in convection heat transfer in the case described above.
[5 marks]

b) Calculate the free-convection heat loss from the outside of the gondola.
[8 marks]

c) How does this compare with the forced-convection loss from such a cylinder with a free-stream velocity of approximately 55cm/s ? [7 marks]

4. A house has a black tar, flat, horizontal roof. The lower surface of the roof is well insulated, while the upper surface is exposed to ambient air at 300 K through a convective heat transfer coefficient of 10 W/m^2K.

a) explain the heat transfer by radiation and why it is the only mode of heat transfer to work in vacuum
[5 marks]

b) For the following equilibrium condition:

Solar radiation to roof + convection from the air to roof = radiation from the roof to the sky

calculate the roof equilibrium temperature for the following conditions

i) clear sunny day with an incident solar radiation of 500 W/m^2 and the ambient sky at effective temperature of 50 K [5 marks]

ii) clear night with an ambient sky temperature of 50 K. [3 marks]

c) if a wind blows during the day and during the night, how would you expect the roof temperature to change ? [2 marks]

PLEASE SEE NEXT PAGE

5. In an industrial application a tube assembly is constructed of pure copper with an inside diameter of 1.1cm, wall thickness of 0.7 mm, and circumferential fins around the periphery. The convection heat transfer coefficient from the tube and fins to the surrounding air is 65 $W/m^{2\circ}C$. The fins have a thickness of 0.2mm and a length of 5mm, and are spaced 6mm apart.

a) explain the term "fin efficiency" and name three different types of fins [5 marks]

b) determine the fin efficiency for this arrangement [7 marks]

c) calculate the thermal resistance for a 6mm length of the tube fin combination [13 marks]

d) for an inside tube temperature of 150°C and the surrounding air temperature of 27°C, calculate the heat loss per meter of tube length [5 marks]