F 01

# FINAL – MEN310 (Heat Transfer)

February 01, 2002

1. The top surface of a car moving at 100 km/h is 1.5-m wide and 1.5-m long. The surface absorbs solar radiation between 0 μm and 1μm with an absoprtivity ($\alpha_\lambda$) of 0.1, between 1 μm and 4μm with $\alpha_\lambda$ of 0.4, between 4 μm and 10μm with $\alpha_\lambda$ of 0.2, and zero absorptivity beyond 10 μm. The incoming solar radiation flux is 698 W/m$^2$, and the temperature of the ambient air is 25°C. Assuming the roof of the car to be perfectly insulated on the interior side, determine the equilibrium temperature of the top surface of the car.

2. Two 3-m long and 4-mm thick wrought iron steam pipes of 10-cm outer diameter are connected to each other through two 1-cm thick flanges of 20-cm outer diameter. The steam flows inside the pipe at an average temperature of 200°C with a heat transfer coefficient of 180 W/m$^2$°C. The outer surface of the pipe is exposed to an ambient at 8°C, with a heat transfer coefficient of 25 W/m$^2$°C.

   a- Disregarding the flanges, determine the average outer surface temperature of the pipe.

   b- Using this temperature for the base of the flange and treating the flanges as fins, determine the fin efficiency and the rate of heat transfer from the flanges. By how much do the flanges increase the heat transfer rate?

3. Liquid oxygen is stored in a thin-walled spherical container 96-cm in diameter, which in return, is enclosed in a concentric container 100-cm in diameter. The surfaces facing each other are plated and have an emissivity of 0.05, and the space in between is evacuated. The inner surface is at 95 K and the whole system is located in a surroundings at 32°C. Determine the heat gained by the oxygen. How does a thin spherical radiation shield of 0.03 emissivity placed midway between the containers affect the heat transfer rate.

4. A car radiator, which can be regarded as a single pass cross flow heat exchanger with both fluids unmixed, consists of 40 tube of 5 mm internal diameter and 600 mm length arranged in a closely spaced plate-fin matrix. In an experiment to determine the overall heat transfer coefficient, hot water enters the radiator at 90°C with a flow rate of 0.6 kg/s and leaves at a temperature of 65°C. Air flows across the radiator and is heated from 20°C to 40°C. Determine the overall heat transfer coefficient of the radiator based on the internal surface area of the tubes.

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Points: 1 (25%), 2 (25%), 3 (30%), and 4 (20%).