ME 320L
Fall 2005 midterm test

Attempt two out of the three questions. If you attempt three, clearly identify the one you do not wish graded.

Clearly state any assumptions, and highlight key intermediate and final results. Briefly describe key steps taken in the development of the solution.

Name:
**Question 1**

For a certain period during curing of freshly poured concrete, the reaction of cement with water releases 240 W/m³. Consider a concrete slab of 0.1 m thickness, poured on an insulating polystyrene foam substrate. If the temperature of the ambient air is 10°C, calculate the maximum temperature in the slab during this stage of curing. The thermal conductivity of concrete is 0.8 W/m/K, and the convection coefficient at the surface of the slab is 4 W/m²/K.

\[ h = 4 \text{ W/m}^2/\text{K} \]

air, \( T = 10 \text{ degrees C} \)
Question 2
A metal water heater tank contains 100 kg of water at 75°C in a room where the ambient temperature is 20°C. The surface area of the heater is 1.3 m². The manufacturer is planning to insulate the heater with matted horse hair (thermal conductivity 0.05 W/m/K), a by-product from the nearby meat packing plant. The technical requirement is that the water should not cool faster than 3°C per hour when the heater is turned off. Calculate the required thickness of the hair mats. Assume that the water circulation by natural convection inside the tank ensures that the water temperature is uniform.

\[ \text{ambient } T = 20 \text{ degrees C} \]

*Hint:* The problem can be made easier by neglecting the temperature drop across the metal tank wall and the air boundary layer around the insulation. Comment on the legitimacy of such an assumption.
**Question 3**
A small spherical hot air balloon, 10 m in diameter, weighs 130 kg with a small gondola and a passenger. How much fuel must be consumed (in kJ/h) if the balloon is to hover at low altitude in still 25°C air? The heat transfer coefficient on the outside of the balloon, resulting from natural convection, is 2.15 W/m²/K.