Closed book. Formula sheet and calculator allowed
Part 1: Multiple choice questions

Attempt all of these questions. Do not give random answers. Random answers will be assigned a score homogeneously distributed in the interval $(-\infty, \infty)$.
1. Consider a cylinder in a cross flow at high Reynolds number. Why does the local convection coefficient \( h_x \) decrease for a while, then again increase as we move along the surface from the stagnation point towards the trailing edge?

   (a) the laminar boundary layer increases in thickness, then becomes turbulent  
   (b) the conductivity of the fluid changes with temperature  
   (c) the boundary layer thickness at first increases, then again decreases

   Answer:

2. The velocity boundary layer is defined as the region of fluid where...

   (a) the velocity is less than the velocity at the same point, for the same geometry, with an inviscid fluid  
   (b) the velocity is zero  
   (c) the velocity is uniform

   Answer:

3. Turbulent boundary layers are usually associated with higher convective heat transfer. In addition, one sees in general:

   (a) lower drag  
   (b) higher drag  
   (c) no change in drag

   Answer:

4. The Reynolds stress in turbulent flow is associated with

   (a) dealing with complicated differential equations  
   (b) the gradient in mean velocity of the fluid  
   (c) the fluctuating component of velocity

   Answer:

5. A high Prandtl number means that

   (a) momentum diffusion is faster than heat diffusion  
   (b) momentum diffusion is slower than heat diffusion  
   (c) the thermal boundary layer develops more slowly than the velocity boundary layer  
   (d) (a) and (c)  
   (e) (b) and (c)

   Answer:
6. Rough surfaces promote boiling more than smooth surfaces. This is because:

(a) the effective interface area is higher  
(b) there are more large bubble nucleation sites  
(c) the vapor/liquid surface tension is reduced

Answer:

7. The tingling noise one hears before water in a heated pot comes to a full boil is due to:

(a) the thermal expansion of the metal in the pot  
(b) the detachment of bubbles from the surface  
(c) the rapid collapse of bubbles due to surface tension

Answer:

8. Natural convection is less effective than forced convection. Why are some new nuclear reactors designed for cooling by natural convection?

(a) it does not rely on pumps to maintain cooling  
(b) it is cheaper  
(c) it works at lower temperatures

Answer:

9. What distinguishes a grey surface from a black surface?

(a) a black surface is a diffuse emitter, a grey surface is not  
(b) the emissivity of a grey surface is less than unity  
(c) the emissivity of a grey surface is independent of the wavelength

Answer:

10. Under what assumptions do we calculate view factors?

(a) grey surfaces  
(b) isothermal surfaces  
(c) convex shapes  
(d) (a) and (b)  
(e) (a) and (c)

Answer:
Part 2: Problems

Choose two of the three problems. If you attempt all three, clearly identify the one you do not wish graded.
Problem 1
A long, horizontal, pressurized hot water pipe of 15 cm diameter passes through a room where the air temperature is 24°C. The pipe surface temperature is 130°C and the emissivity of the surface is 0.95. What is the total rate of heat transfer from the pipe if its length is 10m? Assume the room wall temperature is the same as for the ambient air.
Problem 2
Water droplets at 87°C in a cooling tower have an average diameter of 0.15 cm. The airstream, which moves at a velocity of 0.9 m/s relative to the drops, is at 17°C. Determine:

1. The heat transfer coefficient from the water to the air
2. The instantaneous rate of change of temperature of an average drop

Assume that the drops are far enough apart to not influence each other. State any simplifying assumptions.
Problem 3
A conical hole is machined in a block of metal whose emissivity is 0.5. The hole is 2.5 cm in
diameter at the surface and is 7.5 cm deep. If the metal block is held at 800 K, determine:

1. The view factor from the conical surface to large surroundings,
2. The radiation emitted by the hole to surroundings at 0 K,
3. The value of *apparent* emissivity of the hole, defined as the ratio of the actual power emitted
   by the hole to that power which would be emitted by a black surface having an area equal to
   that of the opening and a temperature equal to that of the inside surfaces.