มหาวิทยาลัยสงขลานครินทร์

คณะวิศวกรรมศาสตร์

การสอบปลายภาค ประจำภาคการศึกษาที่ 2 ปีการศึกษา 2557

วันที่ 9 พฤษภาคม 2558 เวลา 13.30-16.30 น.

วิชา 215-333 Heat transfer หัวหุ่น

คำสั่ง

1. ข้อสอบมีทั้งหมด 5 ข้อ ให้ทำข้อสอบทั้งหมดในสมุดคำตอบ คะแนนเต็ม 100 คะแนน
2. อนุญาตให้นำเครื่องคิดเลข เอกสาร ตำรา Dictionary เข้าห้องสอบได้
3. ห้ามยืมอุปกรณ์ใดๆในห้องสอบ

ผู้ออกข้อสอบ ดร.ภาสกร เวสสะโกศล

1. Consider the flow of water at a rate of 0.01 kg/s through an equilateral triangular duct of sides 2 cm and whose walls are kept at a uniform temperature 100°C. Assume that the flow is hydrodynamically and thermally developed. **[25 Mark]**

   (a) Determine the duct length required to heat the water from 20°C to 70°C.

   (b) Check if the flow is laminar or not.

2.1 A small surface of area A = 8 cm^2 is subjected to radiation of constant intensity I = 10^5 W/(m^2. sr) over the solid angle subtended by $0 \le \phi \le 2\pi$, $0 \le \theta \le \pi/3$. Calculate the radiation energy received by the surface. **[7 Mark]**

2.2 A radiation detector is aimed at a small horizontal surface a distance L = 5 cm away. The line joining the detector axis to the hot object makes $\theta = 45^{o}$ with the normal to the surface of the hot object. The aperture has an area of 0.1 cm^2. **[8 Mark]**

(a) Determine the solid angle subtended by the aperture with respect to the point on the surface of the hot object.

(b) If the hot object is a blackbody of area dA_1 = 100 cm^2 at temperature 1000 K, determine the energy intercepted by the aperture.

3. A double pipe counter flow heat exchanger is used to cool 0.03 kg/s of benzene from 360 K to 310 K with a counterflow of 0.02 kg/s of water at 290 K. If the outer diameter of inner tube is 2 cm and the overall heat transfer coefficient based on the outside area is 650 W/(m^2.K), determine the required length of the exchanger. Take the specific heats of benzene and water as 1880 and 4175 J/(kg.K), respectively. **[20 Mark]**

4. A vertical plate 0.1 m high (along the vertical direction) and 1 m wide (normal to the paper), maintained at a uniform temperature 320 K, is immersed in water at 300 K. **[25 Mark]**

(a) Determine the boundary-layer thickness $\delta(x)$ at x = 0.1 m.

(b) Calculate the local heat transfer coefficient at x = 0.1 m.

5. Consider the laminar boundary-layer flow of liquid metal with the velocity u_∞ and temperature T_∞ along a flat plate kept at a uniform temperature T_w. Derive the expressions for the thermal boundary-layer thickness $\delta_t(x)$ and the local Nusselt number $\mathrm{Nu}_x \equiv hx/k$ by using a linear profile for the temperature distribution given in the form

$$\frac{T(x,y)-T_w}{T_\infty - T_w} = \frac{y}{\delta_t(x)}$$ **[15 Mark]**