

Name.....ID number.....

PRINCE OF SONGKLA UNIVERSITY  
FACULTY OF ENGINEERING

Final Examination: Semester I

Academic Year: 2007

Date: October 2, 2007

Time: 13:30-16:30

Subject: 230-601 Advanced Engineering  
Mathematics for Chemical Engineers

Room: R200

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อนุญาตให้นำเอกสารและเครื่องคำนวณทุกชนิดเข้าห้องสอบได้  
ทุจริตในการสอบโทษขั้นต่ำคือปรับตกในรายวิชาที่ทุจริต  
และพักการศึกษา 1 ภาคการศึกษา

Please do all 5 questions including bonus. Show all your work to receive full or partial credit. Final score is 140. (Total page = 9, including first page)

Question #	Total Score	Score
1	15	
2	15	
3	40	
4	50	
5 (Bonus)	20	
<b>Total</b>	<b>140</b>	

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สุกฤทธิรา รัตนวิไล  
ผู้ออกข้อสอบ

Name.....ID number.....

1. (15 points) Using Laplace Transform solve the differential equation.

$$y'' + 2ty' - 4y = 1$$

$$y(0) = y'(0) = 0$$

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2. (15 points) Evaluate inverse Laplace Transform (**in detail**) of the following equation. Hint: using convolution theory.

$$\frac{1}{(s^2 + k^2)^2}$$

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3. (40 scores) Heating of a finite insulate slab: A slab occupying the space between  $y = 0$  and  $y = b$ , temperature of slab is equal  $T_0$ . At time  $t = 0$  the surface at  $y = 0$  are suddenly raised to  $T_1$  and maintained there. At  $y = b$ , temperature is equal  $T_0$  all time.

3.1 (20 scores) Formulate a partial differential equation

3.2 (20 scores) Find  $T(y,t)$  by using method of Laplace transform (**If you could not solve Inverse Laplace Transform, it is okay**).

For this problem: please introduce the following dimensionless quantities:

$$\theta = \frac{T_1 - T}{T_1 - T_0}, \eta = \frac{y}{b}, \tau = \frac{kt}{\rho C_p b^2}$$

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4. (50 scores) A slab of porous solid 0.5 in. thick is soaked in pure ethanol. The pores are fine, so that molecular diffusion can take place through the liquid in the passages. The effective diffusivity of the system ethanol-water ( $D_{AB}$ ) in the pores is  $1.0 \text{ cm}^2/\text{s}$ . The differential equation of concentration of ethanol ( $C_A$ ) as a function of time ( $t$ ) and distance ( $y$ ) which is measured normal to the center of the slab is following:

$$\frac{\partial C_A}{\partial t} = D_{AB} \frac{\partial^2 C_A}{\partial y^2}$$

For this problem: please introduce the following dimensionless quantities:

$$\tau = \frac{D_{AB} t}{y_0^2}, Y = \frac{C_A}{C_{tot}}, \xi = \frac{y}{y_0}$$

Where:  $y_0$  is the half thickness of the slab

4.1 (40 scores) Find  $Y(\xi, \tau)$  by using separation of variable method

4.2 (10 scores) If the slab is placed in a large well-agitated reservoir of pure water, how long will it take for concentration fraction of ethanol at the center of the slab to fall to 0.009?

Assume: There is no resistance to mass transfer in water phase thus concentration of ethanol in the water and at the surface of the slab, is constant at zero.

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5. (20 scores) A homicide victim was found in a room that is kept at a constant temperature of 70 °F. At 12.00 noon, body temperature measurement was made at time T and another was made one hour later. The results were:

$$T(\tau) = 80^{\circ}F$$

$$T(\tau + 1) = 75^{\circ}F$$

Where time is measured in hours? Assuming that the victim's temperature was 98.6 °F just before death, determine the time of death relative to time point.