Fall 2002 (Przybycien) **42-101 Intro to BME** **NAME: _____**

FINAL EXAM

Format: Open text, notes, homework and mind; closed neighbor.

Part I: Short Answer Questions (72 pts)

Short written-answer and short calculation questions - *No more than two or three sentences in answer to any question in this section please.*

1. (6 pts) Blood is said to have a "yield stress". What is this and why does it occur in blood?

2. (6 pts) The average capillary in the microcirculation has an inner diameter of 0.0008 mm, smaller than the diameter of a red blood cell, which you might think would result in a huge pressure drop. Give two reasons why the pressure drop across the microcirculation is relatively small.

3. (6 pts) Give three reasons why it is much preferred to use a sphygmomanometer on the upper arm rather than on the big toe.

4. (6 pts) Suppose a mathematical expression was available that described the power expenditure, $-\dot{W}$, of an individual swimming in terms of the swimming velocity, $\vec{V}$, the body density, ρ, and the arm stroke length, l; e.g. an equation of the form $-\dot{W} = f(\vec{V}, \rho, l)$ was available. How would you determine from this function, given no other information, if there is an arm stroke length that minimizes the power expenditure?

5. (6 pts) Using our "walking box" model as a basis, describe two different scenarios (in terms of magnitudes of model variables and what they would mean in terms of the characteristics of how someone would walk) where the total rate of energy expended by walking would be dominated by kinetic energy effects.

6. (6 pts) What information does an "ergonomic analysis", say as applied to our "walking box" model, provide?

7. (6 pts) Describe why "allostery" can be considered a form of discrete control in some situations.

8. (6 pts) Several measurements are made of the activity, ν, of a given enzyme as a function of the substrate concentration, S, at a specific temperature and pH; the data are shown at the right. *Just by looking at the data, without doing a calculation,* make a good guess at values for the constants in the Michaelis-Menten equation that might describe the catalytic activity of this enzyme at these conditions. Include units with your guesses and indicate how you arrived at the values of your guesses.

S (mM)	ν (mM product/min)
0.1	0.040
0.5	0.181
1.0	0.322
5.0	1.014
10.0	1.3
50	1.852
100	1.945
500	2.03
1000	2.025

9. (6 pts) From which material would you likely derive the most energy, in the form of ATP, if eaten: 1g of phosphatidyglycerol, 1g of α-maltose, or 1g of hemoglobin? Why?

10. (6 pts) A chemical reaction has ΔG_{rxn} = +4.5 kcal/mol. What would the addition of a catalyst, such as an enzyme, to a solution of the reactants do for this reaction?

11. (6 pts) Celebrex (Searle) and Vioxx (Merck) are nonsteroidal anti-inflammatory drugs (NSAIDs) that are used to treat pain, particularly that associated with rheumatoid arthritis. NSAIDs work by competitively inhibiting cyclooxygenase-2 (COX-2), a membrane-associated enzyme that catalyzes the formation of prostaglandin H_2 from arachidonate. Given that the standard dose of Celebrex is 200 mg and that of Vioxx is 25 mg, which drug likely has the largest K_I value? Why?

12. (6 pts) Describe three differences between procaryotes and eucaryotes.

Part II: Detailed Questions (78 points)

1. (26 pts) Phashun Plait, a student at a neighboring university, has taken to wearing 6.0 in high platform sneakers that weigh 2.7 lbm each, heedless of the implications with respect to optimum stride length and energy expenditure during walking; assume that "regular" shoes have 1.0 in heels and weigh 1.0 lbm each. You decide to help Phashun out with a few calculations. Before slipping into any shoes, Phashun weighs 135 lbm with 36% of that accounted for by total leg mass and is 3.2 ft from heel to hip. Phashun walks 4.0 miles per hour when late for class.
   a. (13 pts) By what fraction does Phashun's optimum stride length change when going from regular shoes to platform sneakers (and when late for class)?
   b. (13 pts) By what fraction does Phashun's minimum rate of energy expenditure change when going from regular shoes to platform sneakers (and when late for class)?

2. (26 pts) Blood flows through an aorta with a 1.0 cm inner diameter at an average velocity of 50.0 cm/s at an average pressure of 100 mmHg. This blood enters a region of stenosis (a narrowing, perhaps due to a sclerotic plaque) where the inner diameter is only 0.50 cm. The viscosity of the blood is 3.0 cP.
   a. (16 pts) Make a good estimate of the average pressure, in mmHg, in the narrow region.
   b. (10 pts) Is the flow in the narrowed region laminar or turbulent?

3. (26 pts) The basal metabolic rate, BMR, of newborns is given by the correlation:

$$BMR = 0.054W^{1.5}H$$

   where BMR is in kcal/hr, W is weight in kg and H is height in cm.
   a. (6 pts) What are the units of the constant 0.054 in the equation above?
   b. (6 pts) Rewrite the equation above so that BMR may be calculated by plugging in values for W in lbm and H in inches.
   c. (6 pts) A large population of infants from a given nursery is found to have W = 4.5 ± 0.7 kg and H = 40.2 ± 9.9 cm; here population data is given as the (mean ± one standard deviation). Determine the value (mean ± one standard error) for the BMR in kcal/hr for this population of infants.
   d. (8 pts) If 20 such infants were present in a well-insulated nursery and the air conditioning failed, at what rate in °C/hr (mean ± one standard error), would the temperature rise in the nursery? You may assume a room volume of 499 m^3, ρ_{air} = 1.1769 kg/m^3, and Cp_{air} = 0.2405 kcal/(kg•°C).