THE UNIVERSITY OF BRITISH COLUMBIA

Science 1 Math/Phys

Second Midterm

18 November 1999

TIME: 50 MINUTES

FULL NAME: ______________________ STUDENT # : ______________

SIGNATURE: ______________________

This Examination paper consists of 8 pages (including this one). Make sure you have all 8.

INSTRUCTIONS:

Write your name on every page.

No memory aids allowed.

MARKING:

Q1	/30
Q2	/40
Q3	/30
TOTAL	/100

NAMES OF INSTRUCTORS: Mark MacLean, Jess H. Brewer & Domingo Louis-Martinez

Q1 Hummingbird Helper [30 marks]

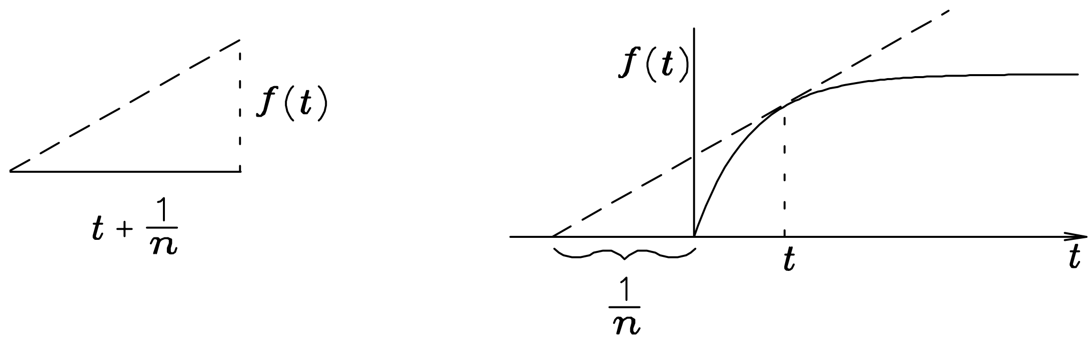
In considering the strategy a hummingbird should follow to maximize the total energy R gained per total time spent foraging, we derived the following expression:

$$R(t) = \frac{n\,f(t)}{1+n\,t} = \frac{f(t)}{t+1/n},$$

where n was the number of (identical) patches, t is the time spent in *each* patch and $f(t)$ is the total energy gained from one patch as a function of the time spent in that patch. In class we postulated a specific form for the function $F(t)$ and carried out the optimization procedure on $R(t)$ for that particular function $f(t)$.

Show how to optimize $R(t)$ for a function $f(t)$ whose general *shape* is known but whose functional form is unknown. If you wish, you may choose to draw two or three differently shaped graphs for possible functions $f(t)$; try to make them biologically reasonable.

Hint: Consider the geometry illustrated below:



YOUR FULL NAME:

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Q2 Radiation Effects [40 marks]

The harmful effects of a 2 Gray (200 rad) whole-body dose of gamma rays can be crudely modelled by stating that the affected person's probability $\mathcal{P}$ of still being alive at a time t after the exposure is approximated by the function

$$\mathcal{P}(t) \;=\; e^{-\lambda t} + \lambda t e^{-\lambda t}.$$

(This function is, of course, invalid for *very* large t.)

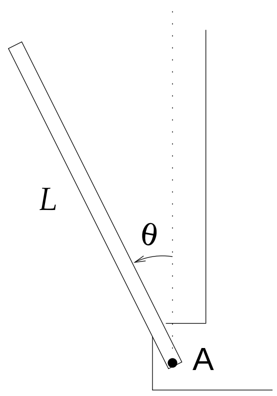
(a) Sketch the function $\mathcal{P}(t)$.

(b) Explain in words what is represented by the function $\mathcal{Q}(t) \equiv -\dfrac{d\mathcal{P}}{dt}$.

(c) Sketch the function $\mathcal{Q}(t)$.

(*d*) If the most probable time of death (in this model) is 10 years after the exposure, what is the value of λ?

Q3 Swinging Rod [30 marks]



A thin, uniform rod of mass $m = 1$ kg and length $L = 1$ m is attached to a fixed wall bracket at A by a frictionless pin through its end. The rod is initially at rest in an upright vertical position ($\theta_o = 0$). It is then given a slight "nudge" so that it begins to fall, as shown.

At the instant when the rod is oriented vertically downward ($\theta = \pi$), *what is the force exerted on the rod by the pin?*

YOUR FULL NAME:

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YOUR FULL NAME: