The University of British Columbia

Sessional Examination - April 22 -1997

Physics 438

Time 2 1/2 hrs

Candidates Name:...

Registration #:.......................................

Candidates Signature ....

This is an open -lecture -notes exam

The exam has three parts;

Part A: Select 2 out of 4 questions
Part B: jellyfish *polyochis*
Part C: Write an essay on one of the topics

show all your rough work,

If you think some necessary information is missing make an "educated guess" namely quote a number and write down why this number would makes sense.

	A: select 2 out of 4 questions					Part B	Part C	
Question	1	2	3	4		jellyfish	essay	total
max. mark	20	20	20	20		20	40	100
mark								

Part A: Solve 2 out of the following 4 questions.

1) Metabolic rates of spiders and caterpillars

In summer time a 500mg spider catches a meal about once a day (Δts,), in winter it goes on average for a 6 weeks without eating. (Δtw). Assume that the spider's prey weighs 100mg on average. What the spider eats is going into its metabolic processes. Remember that the spider only "eats" the soft tissue (fat & proteins) and discards the empty shells. Assume that 1 g of fat and protein body tissue contains 25kJ

a) Make a reasonable assumption of the percentage of bodymass of the prey which the spider eats and calculate the average energy content ΔQ of a meal extracted by the spider.

b) calculate the metabolic rate $\Delta Q/\Delta t$ in summer time and in winter.

c) Do a similar calculation for 100 mg plant eating caterpillar , who consumes 20 times its body weight in a day. Assume that the plant tissue contains about 6% of useful edible starches and proteins which have an energy content of about 21kJ/g.

d) Plot your results on the logarithmic plot Fig. 1, which already shows the metabolic rate curve of warm blooded animals (mouse to elephant curve), and explain if your results make sense compared to the mouse to elephant curve.

2) The voice of a frog.

Frogs croak at frequencies from 1000 to 8000 Hz. How is this sound generated? Like an open organ pipe, like a closed organ pipe or like a Helmholz resonator?

$V=12cm^3$
$a = 0.8\ cm^2$
$L = 1.5cm$

a) Which part of the frog would act as an organ pipe? Calculate the fundamental frequency and the first overtone of an open organ pipe and a closed organ pipe with the dimensions given above.

b) Calculate the frequency of a Helmholtz generator with the dimensions given above.

c) Look a your results of (a) and (b) and conclude which mechanisms is likely at work.

d) What would the frog have to do in order to lower its frequency in case (a) and case (b)?

3) Wicket Cricket

A cricket player throws a 0.3kg ball with stiff arm over his head. Suppose he starts the throw at the position (1) and swings his arm through an arc of 30°, using only his deltoid muscle.
How fast is the ball when he lets go in the position (2)?

To answer this question use the geometry of the muscles as shown, take the dimensions of your own arm, and assume for the calculation that the arm is a stiff member, Mass M, length L, like a beam with constant cross section hinged at one end.

$I= (1/3)\ ML^2$. Specific muscle force $f = 2\ 10^5\ N/m^2$.

Explain all your assumptions, and approximations.

(a) estimate the cross section of the Deltoid muscle and calculate its force,

(b) calculate the average torque applied to rotate the arm.

[hint: you may simplify the problem by approximating the geometry so that you evaluation is more an estimate than a precise calculation, however describe at the end if your method yields too small or too large a velocity]

(c) Estimate the mass of the arm and calculate the mass moment of inertia for this rotation.

(d) calculate the angular acceleration

(e) calculate the time it takes to rotate the arm from rest at position (1) to position (2).

(f) calculate the angular velocity of the arm at position (2)

(g) calculate the linear velocity of hand and ball at position (2). What is the kinetic energy of the ball and the arm at this instant?

(h) discuss how the speed of the ball could be increased.

4) Owls eyes

Owls hunt at night using eyes and ears. A big horned owl has about the size of a small turkey. Assume that the owls eye is a scaled version the human eye, with eyelid, iris, lens, and retina.

Estimate the size of the eye ball, and then determine (by comparison with the human eye, Fig. 6-8)

(a) the focal length, and the diameter of the iris when fully open (assume that the iris has a circular shape);

(b) Find for blue light, l= 480 nm, the diffraction limited angular resolution (the angle at which the first order diffraction minimum occurs), and determine at which distance L the owl would reckognize two glow worms which are located 12 mm apart as two objects rather than a single burred glowing point.

(c) Determine the amount of light intensity which this eye would collect when looking from a distance of 50 m at a point source (say a glow worm) emitting 6 μ watt of light power in a perfectly dark night (no moon, dark overhead clouds to obscure the stars).

(d) How many photons would this eye collect in one "blink" (1 blink = 1/15 sec). At which distance would the photon flux be so small that the owl could no longer see the glow worm.

(e) Why was a "perfectly dark night specified in part c?

Part B **Jelly fish escapes*polyorchis megilliensis***

A jelly fish of an average radius of 2.0 cm ejects 7 ml of water in 0.5 sec through a circular hole of 1.5 cm diameter.

a) Calculate the mass flow rate and the average ejection velocity of the water

b) Find the "rocket" thrust force

c) Assuming that this rocket force was constant in time.... give the drag force first as function of velocity, and then determine the "terminal velocity" where the rocket thrust force is equal to the drag force.nwater $=10^{-6}$ [m^2/s,] hwater=10^{-3}[kg/ms]

[Hint: initially one does not know the drag coefficient, because the velocity of the squid is unknown. Make a reasonable guess of the velocity (it would neither be 1 mm/sec nor would it be 1km/sec) and find the drag coefficient from Fig. 3-28d.]

Part C Essay (typically 200- 300 words) on one of the topics

(a) Size:
What is the benefit of beeing small or large and what limits the size? :
Describe some physical effects which small animals can utilize in their niche, and what physical effects give a lower limit to the size, and
describe some physical effects which big animals use to their advantage and what physical effects limit the maximum size of animals.

(b) Why do animals need distant senses: describe the dominant distant sense of one of the animals

- bat, monkey, shark, octopus, dolphin, honey bee, crow, , .

Answer the questions (i) Is there a relation between the size of the animal and the range of distance of its dominant distance sense? (ii) Do land animals rely more on sight and sea animals more on sound? If so why? (iii) How can the senses be confused. (iv) How are the senses affected by daily or seasonal changes in the environment ?

(c) Describe the physical principles which one of the animals below uses to survive in its niche.

- aligator, bat, crow, dolphin, honey bee, monkey, octopus, pit snake, shark, wolf.