Physics 1090 Homework #6

Due Thursday, October 22, 2:00 pm

Reading assignment: Chapters 13, 14 of the notes.

1. In an experiment on scaling carried out in 1883, a dog of mass 3.2 kg. and surface area 2400 sq. cm. was found to need 280 Calories a day to stay alive and warm (no exercise or weight change). A dog of mass 10 kg. and surface area 5300 sq. cm. was found to need 650 Calories a day, yet another dog of mass 20kg. and surface area 7500 sq. cm. needed 920 Calories a day.

(a) Do the calorie requirements correlate better with mass or surface area? Explain what you would expect. How precise would you expect the correlation to be?

(b) Make an estimate of your own mass and surface area, and, assuming you are doglike for purposes of this question, how many calories do you need a day to stay alive, without exercise and at constant weight? (Hint on surface area: how big a towel will pretty much cover all your skin?)

(You can find out more about the dogs— and humans—by Googling Meeh coefficient.)

2. You probably eat about 2% of your weight in food each day. Assuming that figure, estimate or find out what fraction of its weight a mouse eats daily, and explain why it needs that amount.

3. Galileo discovered that the time of swing of a pendulum varies as the square root of the length: for a pendulum one meter long, it's very close to one second for a single swing from one side to the other.

In relaxed walking, the legs swing like pendulums (try it!). Suppose A's legs are 20% longer than B's legs, but of the same shape, and when they walk, both swing their legs through the same angle. How much faster does A walk than B?

4. The text below is a direct copy from Galileo's own introduction to his work on acceleration, one of the most important concepts in physics.

Read it carefully, and then *write an explanation in your own words, including drawing a graph of speed as a function of time for an object falling from rest*. **Note: for the word "momenta" he uses, you can just substitute "speed".**

(Galileo's diagram below is itself a graph of speed against time, but he drew it before there were standard ways of graphing anything, so it's a bit puzzling at first sight … but spend some time going through what he says, and you'll be able to interpret the figure.)

THEOREM I, PROPOSITION I

The time in which any space is traversed by a body starting from rest and uniformly accelerated is equal to the time in which that same space would be traversed by the same body moving at a uniform speed whose value is the mean of the highest speed and the speed just before acceleration began.

Let us represent by the line AB (*see figure below*) the time in which the space CD is traversed by a body which starts from rest at C and is uniformly accelerated; let the final and highest value of the speed gained during the interval AB be represented by the line EB, drawn at right angles to AB; draw the line AE, then all lines drawn from equidistant points on AB and parallel to BE will represent the increasing values of the speed, beginning with the instant A. Let the point F bisect the line EB; draw FG parallel to BA, and GA parallel to FB, thus forming a parallelogram AGFB which will be equal in area to the triangle AEB, since the side GF bisects the side AE at the point I; for if the parallel lines in the triangle AEB are extended to GI, then the sum of all the parallels contained in the quadrilateral is equal to the sum of those contained in the triangle AEB; for those in the triangle IEF are equal to those contained in the triangle GIA, while those included in the trapezium AIFB are common. Since each and every instant of time in the time-interval AB has its corresponding point on the line AB, from which points parallels drawn in and limited by the triangle AEB represent the increasing values of the growing velocity, and since parallels contained within the rectangle represent the values of a speed which is not increasing, but constant, it appears, in like manner, that the momenta [momenta] assumed by the moving body may also be represented, in the case of the accelerated motion, by the increasing parallels of the triangle AEB, and, in the case of the uniform motion, by the parallels of the rectangle GB. For, what the momenta may lack in the first part of the accelerated motion (the deficiency of the momenta being represented by the parallels of the triangle AGI) is made up by the momenta represented by the parallels of the triangle IEF.

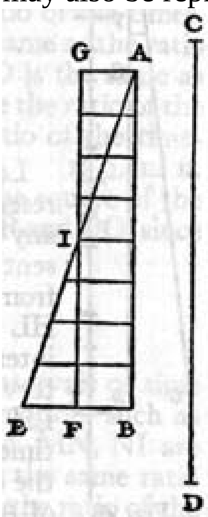

Fig. 47

Hence it is clear that equal spaces will be traversed in equal times by two bodies, one of which, starting from rest, moves with a uniform acceleration, while the momentum of the other, moving with uniform speed, is one-half its maximum momentum under accelerated motion. Q.E.D.