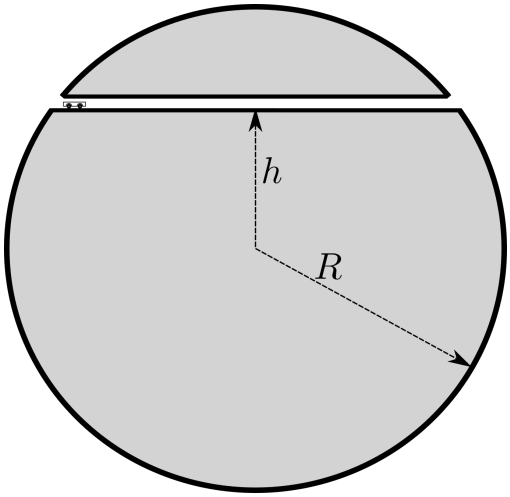
EXAM 1. Wednesday, July 8, 2020, 10am to 11:35am

Problem 1. *A Cart in the Earth*

1. A straight narrow shaft is drilled in the Earth as shown in the figure. What time will it take for a cart to travel from one end to another with zero initial velocity? Neglect air resistance, friction, and Earth rotation. Take the Earth to be a uniform sphere. Express your answer through the acceleration of free fall g and Earth radius R and length h.

2. How does this time depend on h?



Problem 2. *Bullet and Block*

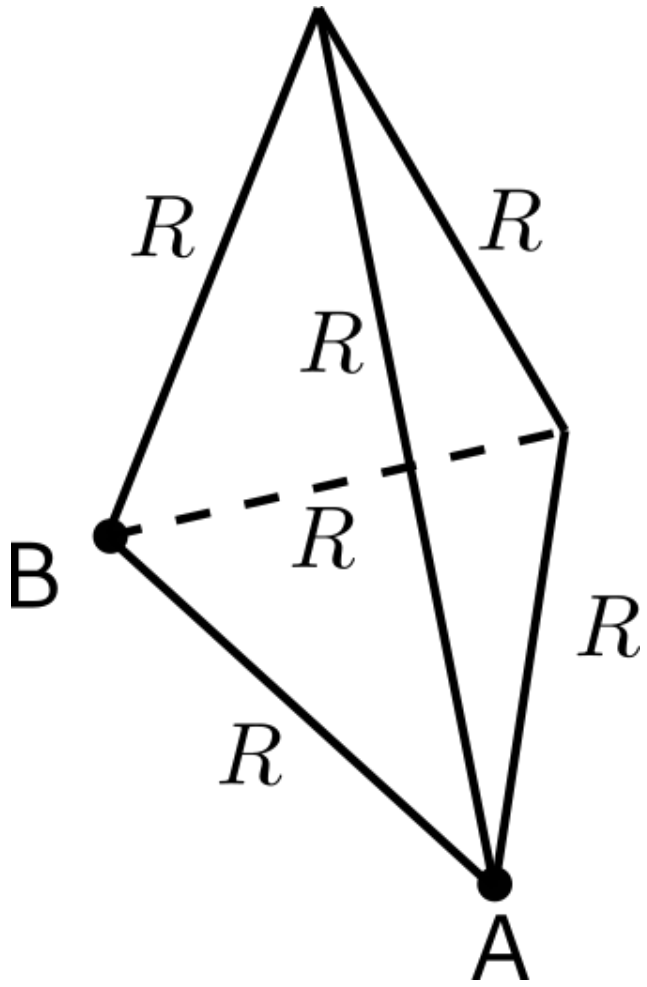
A bullet of mass m and velocity v hits a block of mass M and gets stuck in it. The block is initially at rest on a frictionless table. The spring constant of the spring is k, see figure.

1. What will be the frequency of the oscillations after the bullet is stuck in the block?

2. What will be the amplitude of the oscillations?

Problem 3. *Tetrahedron of resistors.*

A tetrahedron is made of metal wire. The resistance of each link is R. Find the resistance between the points A and B.

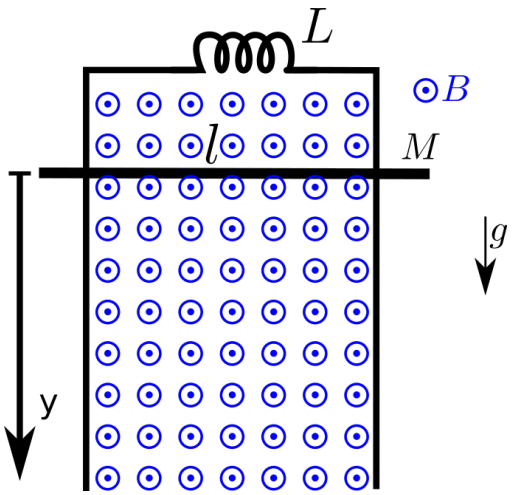

R
R
R
R
R
R
B
A

EXAM 2. Final. Tuesday, August 4, 2010, 10:30am-12:30pm

Problem 1. *Vertical Rails with inductor*

Long enough vertical rails distance l from each other made of an ideal conductor are connected by an inductor L. A bar of mass M, also made of an ideal conductor, can slide along the rails without friction and without loosing electrical contact with the rails. A uniform magnetic field B is horizontal and perpendicular to the plane of the rails. At some point the bar was released with zero initial velocity. Neglect all resistances. Initial current in the inductor is zero.

Find $y(t)$ – the height of the bar as a function of time if $y(0) = 0$.



Problem 2. *Wave function and expectations*

For a particle in a quantum mechanical state given by a wave function $\psi(x) = Ce^{-|x|/\lambda}$ find:

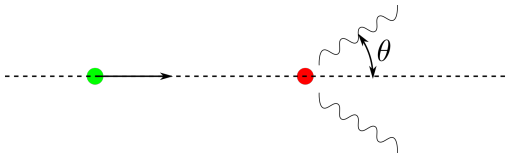
1. The normalization constant C.
2. The probability to find the particle somewhere in the interval between $-\lambda/2$ and $\lambda/2$.
3. The average position $\bar{x}$.
4. The standard deviation from the average position $\Delta x = \sqrt{\overline{x^2} - \bar{x}^2}$.

Hint: you might need the following integrals: $\int_0^\infty e^{-x}dx = 1$, $\int_0^1 e^{-x}dx = 1 - e^{-1}$, *and* $\int_0^\infty x^2 e^{-x}dx = 2$.

Problem 3. *Electron-positron annihilation*

An electron (rest mass m_e) of total energy E makes a head-on collision with a positron, which is initially at rest. Positron is electron's antiparticle, it has the same mass as electron, but opposite charge. In collision the two particles annihilate each other and are replaced by two photons (γ rays) of equal energy, each traveling at equal angles θ with electron's direction of motion. Find

1. The energy ϵ of each photon.
2. The momentum p of each photon.
3. The angle θ.



THE END!