Physics 310 - Assignment #1 - Due September 14^{th}

1. *(Fowles and Cassiday, problem 1.7)*
   For what value (or values) of q is the vector $\vec{A} = q\hat{\imath} + 3\hat{\jmath} + \hat{k}$ perpendicular to the vector $\vec{B} = q\hat{\imath} - q\hat{\jmath} + 2\hat{k}$?

2. *(Fowles and Cassiday, problem 1.17)*
   A small ball is fastened to a long rubber band and is twirled around in such a way that the ball moves with an elliptical path given by the equation

   $$\vec{r}(t) = \hat{\imath} b \cos\omega t + \hat{\jmath} 2b \sin\omega t$$

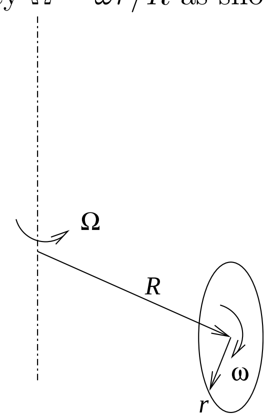
   where b and ω are constants. Find the speed of the ball as a function of t. In particular, find v at $t = 0$ and at $t = \pi/2\omega$, at which times the ball is, respectively, at its minimum and maximum distances from the origin.

3. *(Fowles and Cassiday, problem 1.19)*
   A bee goes out from its hive in a spiral path given in plane polar coordinates by

   $$r = be^{kt} \qquad \theta = ct$$

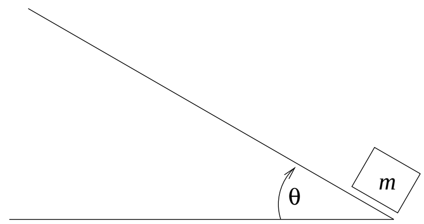
   where b, k and c are positive constants. Show that the angle between the velocity vector and the acceleration vector remains constant as the bee moves outward.

4. A wheel of radius r rolls with a constant angular frequency ω around in a circle of radius R with a constant angular frequency $\Omega = \omega r/R$ as shown:

   Calculate the velocity $\vec{v}$ and acceleration $\vec{a}$ of a point on the rim of the wheel as a function of time.

5. A block of mass m is initially located at the bottom of an incline plane which has a coefficient of sliding friction μ_κ as shown:



If the block is given an initial velocity v_0 up the ramp, at what time will it return to the bottom of the ramp?

6. *(Fowles and Cassiday, problem 2.17)*
If the force acting on a particle can be written as the product of a function of the distance and a function of the velocity, $F(x,v) = f(x)g(v)$, show that the differential equation of motion can be solved by integration. If the force is a product of a function of the distance and a function of time, can the equation of motion be solved by simple integration? Can it be solved if the force is a product of a function of time and a function of velocity?

7. *(Fowles and Cassiday, problem 2.14)*
A particle of mass m is released from rest a distance b from a fixed origin of force that attracts the particle according to the inverse square law:

$$F(x) = -\frac{k}{x^2}$$

Show that the time required for the particle to reach the origin is

$$\pi\left(\frac{mb^3}{8k}\right)^{1/2}$$

8. *(Fowles and Cassiday, problem 2.11)*
A metal block of mass m slides on a horizontal surface that has been lubricated with a heavy oil so that the block suffers a viscous resistance that varies as the 3/2 power of the speed:

$$F(v) = -cv^{3/2}$$

If the initial speed of the block is v_0 at $x = 0$, show that the block cannot travel farther than $2mv_0^{1/2}/c$.