1. (12%)

A rock tied to a rope moves in the xy- plane; its coordinates are given as functions of time by

$$x = R\cos\omega t \qquad y = R\sin\omega t$$

where R and ω are constants. (a).Show that the rock's distance from the origin is constant and equal to R, that is, that its path is a circle of radius R. (b).Show that at every point the rock's velocity is perpendicular to its position vector. (c).Show that the rock's acceleration is always opposite in direction to its position vector and has magnitude $\omega^2 R$. (d).Show that the magnitude of the rock's velocity is constant and equal to ωR.

2. (12%)

After the engine of a moving motorboat is cut off, the boat has an acceleration in the opposite direction to its velocity and directly proportional to the square of its velocity. That is, $dv/dt = -kv^2$, where k is a constant.

(a). Find the magnitude v of the velocity at a time t after the engine is cut off.

(b). the distance x traveled in a time t.

(c).the velocity after traveling a distance x.

3.(12%)

Find the moment of inertia of a uniform solid sphere with radius R and mass M ,when it is rotating about an axis tangent to it.

4.(20%)

A region in space contains charge that is distributed spherically such that the volume charge density ρ is given by

$\rho = \alpha$ for $r \le R/2$,

$\rho = 2\alpha(1-r/R)$ for $R/2 \le r \le R$,

$\rho = 0$ for $r \ge R$.

The total charge Q is 3.00×10^{-17}C,the radius R of the spherical charge distribution is 2.00×10^{-14}m, and α is a constant having units of C/m^3 (a).determine α in terms of Q and R, and also determine its numercial value. (b).using Gauss's law, derive an expression for the magnitude of the electric field as a function of the distance r from the center of the distribution. Do this separately for all three regions. Be sure to check that your results agree on the boundaries of the regions. (c).If an electron with charge q' = -e is oscillating back and forth about r = .0 (the center of the distribution) with an amplitude less than R/2, show that the motion is simple harmonic.

5.(12%)

The region between two concentric conducting spheres with radii a and b is filled with a conducting material with resistivity ρ. (a) Find the resistance between the spheres. (b). Derive an expression for the current density as a function of radius, if the potential difference between the spheres is V_{ab}.

6.(20%)

Prove the thermal efficiency of a Carnot engine is .

$$e = 1 - \frac{T_c}{T_H}$$

7.(12%)

Explain the following terms in words.

(a).The second law of thermodynamics.

(b).The concept of electric field.

(c).Conservative force.