ME-573 Homework 3

(Note: Do all problems for full credit (25 points each))

Problem 1:

Use truncated Taylor series expansions to estimate the relations for mean and variance of the following arbitrary functions of random variables. Note:

If $y = f(X_1, X_2, ... X_n)$

then $E[y] = f(E[x_1], E[x_2], ... E[x_n])$

and $V[y] = s.d._y^2 = \sum_{i=1}^{n} \left(\dfrac{\partial y}{\partial x_i} \right)^2 s.d._{x_i}^2$

a) $Y = \sqrt{X_1^2 + X_2^2}$ (Pythagorean theorem where X_1 and X_2 are R.V.'s)

b) $I = \dfrac{1}{12} bh^3$ (Moment of inertia for a rectangular section where b and h are R.V.'s)

c) $\omega = \sqrt{\dfrac{k}{m}}$ (Natural frequency where k and m are R.V.'s)

Problem 2:

A description of the likely load statisics are needed for a proposed design. The definition should be quite precise; thus 20, 30, and 50 measurements are proposed to be made from a population with a known variance, $(s.d.^2 = 10\ kN^2)$. Use the central limit theorem to determine the a priori probability (for each proposed sample set size) that the sample mean will be obtained for which $\bar{L}$ will differ from μ_L by less than 1 kN. If 95% probability is required, which of the proposed sample set sizes should be employed? As the number of samples in a set increases, what is the trend in the dispersion of the sample mean about the population mean?

Problem 3:

For a certain cam/follower system, determine the statistics of the vertical force acting through the follower if the force acting at the cam surface at this instant is $\bar{R}, s_R$ (39000, 7070) N at 30° to the vertical. Assume the vertical and horizontal reaction forces are correlated random variables.
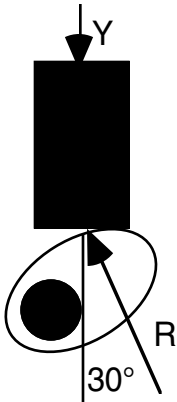
Problem 4:

Given the 50 load values shown:

a) Determine the mean and standard deviation of the load using the usual formulae.
b) Estimate the mean and standard deviation of arbitrarily selected sample sets of 5, 10, and 25 loads using Table 3.4 and the ranges of each sample set?
c) Can reasonable estimates of statistics be made from the ranges alone?

Load values (N)

3.7	5.4	4.4	4.4	3.4	4.8	4.9	5.1	3.5	4.1
4.3	3.7	1.6	2.7	7.4	2.9	3.9	0.6	2.7	4.7
4.6	4.1	3.3	6.5	3.0	3.1	5.2	3.7	1.7	5.0
2.3	3.7	4.2	3.6	3.4	4.0	2.7	3.8	4.1	2.6
2.9	1.9	3.1	4.7	4.5	5.9	3.0	4.1	4.3	5.3