ME 563 HOMEWORK # 8 Fall 2008

PROBLEM 1: (35%)

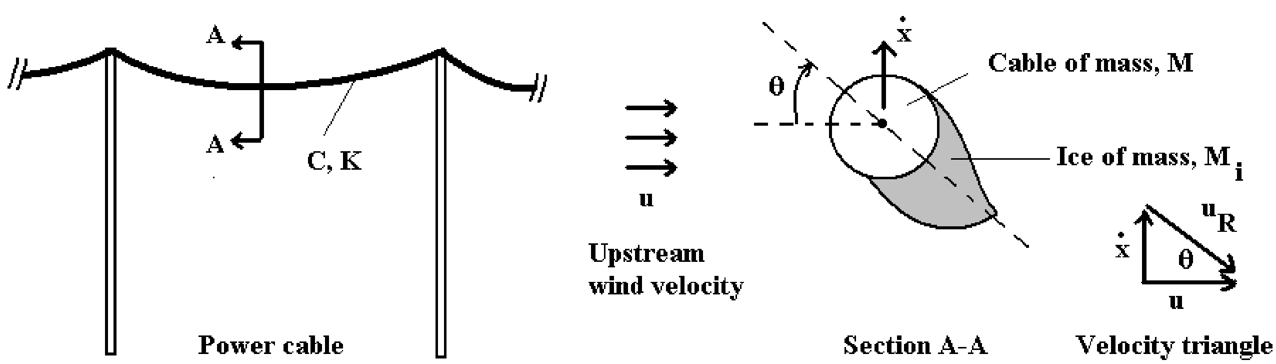
During the winter months, power cables can become coated with ice as shown in the figure below. The ice creates an asymmetric aerodynamic surface overwhich wind blows causing the power cables to 'gallop' and eventually vibrate loose from their supports. 'Galloping' or 'flutter' occurs in this case when the effective damping of the vibrating cables becomes negative. If the angle of attack, θ, which is the angle between the upstream wind velocity, u, and the relative velocity, u_R, is relatively small, then find the maximum wind velocity that will not produce galloping of the cable (mass M, viscous damping C, vertical stiffness K) given that the vertical force on the ice-covered cable (ice mass M_i) is,

$$F = \frac{1}{2}\rho u^2 W C_x$$

where C_x is a force coefficient given by,

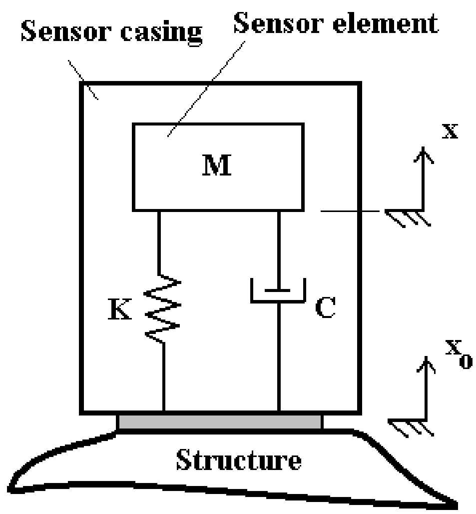
$$C_x = \left(\frac{u_R}{u}\right)^2 \left[C_L \cos\theta + C_D \sin\theta\right]$$

with lift coefficient, C_L, and drag coefficient, C_D, and W is the area of the ice-covered cable. Assume all constants are known and that the cable can be modeled as a SDOF system. Comment on the result.



PROBLEM 2 (30%)

You would like to use the sensor below to measure the *displacement* of the structure. Assume that the output measurement from your sensor is proportional to the relative displacement between the base and the sensor element and that the casing is rigidly attached to the structure. Plot and describe the frequency response characteristics of this sensor for different values of the design parameters (M, C, and K). How would you design this sensor to make the best measurements? Can you measure the static displacement of the structure? Explain.



PROBLEM 3 (35%)

Calculate, plot, and explain the frequency response function between the weighted unbalance mass, *me*, and the dynamic unbalance, MX_p, where X_p is the dynamic steady state displacement of the attachment point of the engine nacelle on the wing below when the rotor is spinning at a speed of *N* RPM, *M* is the total mass of the rotor-blade assembly, *m* is the unbalance mass of the rotor-blade assembly, and *e* is the eccentricity of unbalance. You will also need to calculate the effective mass of the wing as it undergoes vibration from the reciprocating imbalance of the engine. How would you design the nacelle attachment mount to eliminate the vibration amplitude of the wing at a rotational speed of *N* RPM? Show any associated frequency response functions associated with your proposed design.