國立成功大學機械工程學系

機械振動學(Mechanical Vibrations)

Spring Term 2022

QUIZ I

April 11 2022 (Monday)
6:30 – 8:30 PM

RM. 91204

Note:
Problem I: Close Book/Close Notes
Rest Problems: Close Book but a A4 sheet of notes is permissible

先做第一題. 第一題交卷後, 可拿出預先準備的 Note Sheet, 做其他的題目.

共 8 大題

Total 120 Points

Part I. Closed books/notes (8 Problems, 40 Pts, 5Pts/each)

Problem 1. Please briefly answer the following questions (Closed books/notes)

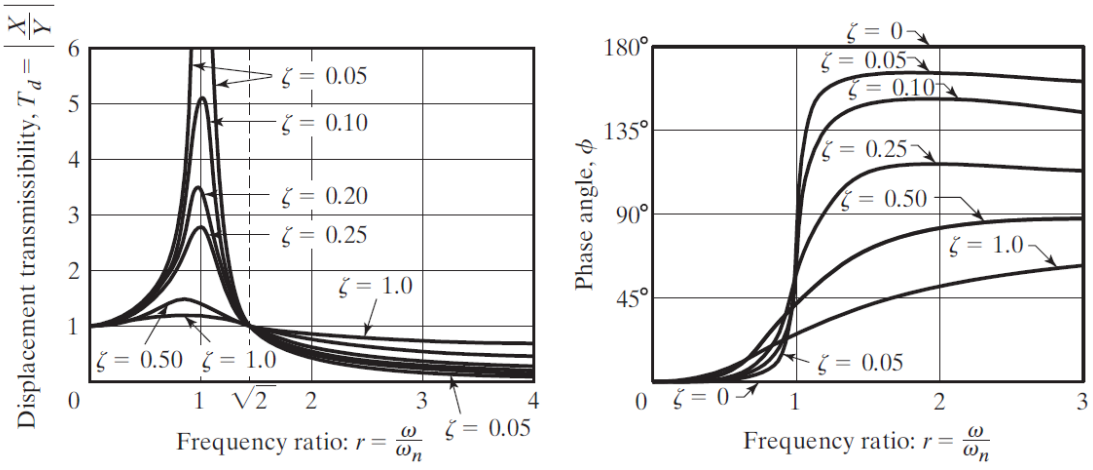
A. Consider the Boeing 777-200 shown below. You are asked to model the wing vibration by a SDOF model by using the wing tip deflection as the main displacement variable. However, you need to find the system parameter by yourself. Please tell me your approach to establish the model (via experiments and/or analytical mechanics).

B. Consider a mass-spring system with spring constant K and mass M. Please show that its natural frequency $\omega_n^2 = g/\Delta$, where g is the gravitational acceleration and Δ is the static deflection due to gravity.

C. What assumptions are made in finding the natural frequency of a single- degree- of freedom system using the Rayleigh method?

D. In class, we have introduced viscous damping, friction damping, and hysteresis damping. Please try your best to tell us the difference in vibration of a mass-spring system with the above three types of dampers.

E. Consider the following figure, please define the term *displacement transmissibility*. In addition, for a SDOF system with m=1 Kg, c = 7 N.s/m, k=1000N/m, subjected to an external vibration with ω=25 rad/s, please estimate its transmissibility.



F. In vibration, we use 3 difference terminologies to description the damping capacity of a system. They are *damping ratio*, *loss factor*, and *quality factor*. Please make a brief description on each of them and explain their differences.

G. In class, we have utilized phasor concept to qualitatively describe the relation between applied force and the resulted vibration displacement. For $\omega/\omega_n = 1$, please draw its phasor relation diagram and show us if damping coefficient $c \rightarrow 0$, the vibration amplitude $\rightarrow \infty$ for a given force amplitude.

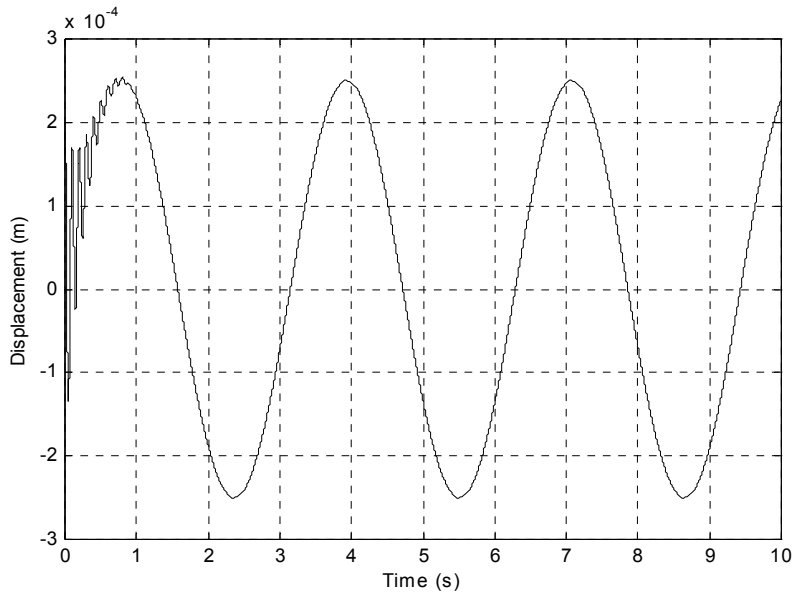
H. In class, we have briefly mentioned some flow-induced vibration issues. Please state the galloping phenomenon. In addition, please also tell us the main application of the Stockbridge damper shown below.

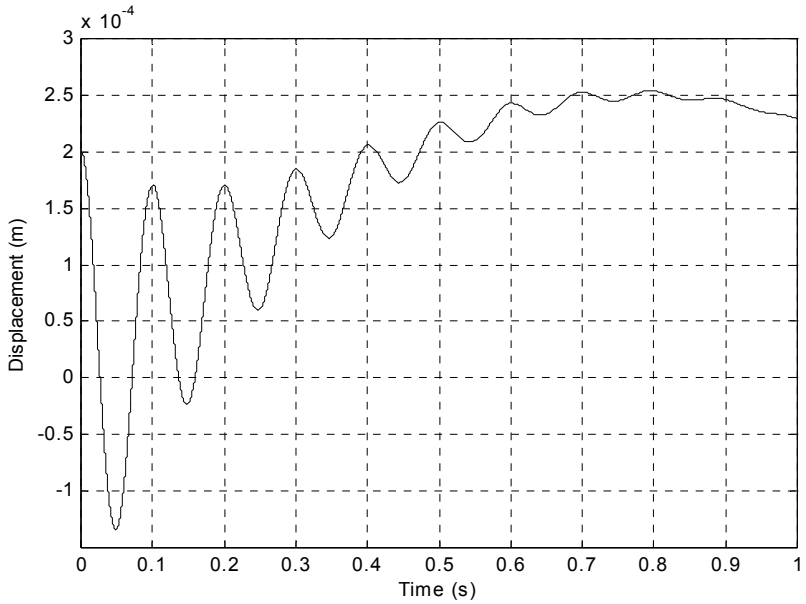
Part II. A sheet of notes is permissible (7 Problems, 80 Pts)

Problem 2. *(Experimental Extraction of System Parameter)* ***(12 Pts)***

Consider the forced response of a system shown in the following two figures. The force input is a sine wave with a forcing amplitude =1N, please identify the necessary system parameters (i.e., system mass, damping coefficient, spring constant, and the frequency of the force input.)

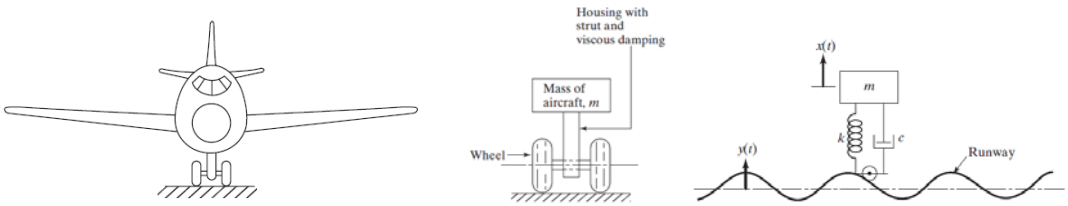
*第二張圖是第一張圖在 t = 0 – 1 秒 的放大圖





Problem 3. (12 Pts)

The landing gear of an airplane can be idealized as the spring-mass-damper system shown below. If the runway surface is described $y(t) = y_0 \cos \omega t$, if k=5×10^6 N/m, determine the value of *c* that limit the amplitude of vibration of the airplane (*x*) to **0.1 m**. Assume **m=2000 Kg**, **y_0=0.2m**, and **ω=157.08 rad/s**.



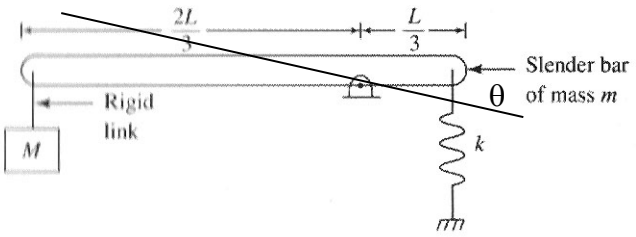
Problem 4. (16 Pts)

Consider the system shown in the following figure.

(a) Is the system a conservative system? Why? (4 Pts)

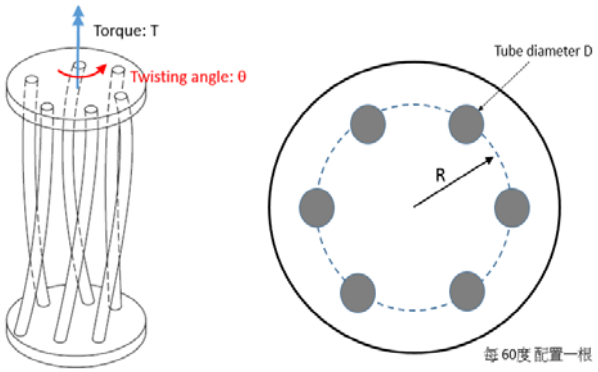
(b) Please use θ as the variable and express the kinetic energy and potential energy of this system (6 pts)

(c) Please find the equation of motion and its natural frequency (6 pts)



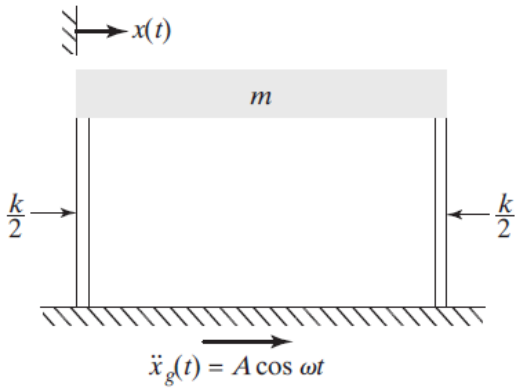
Problem 5. (10 Pts)

A heat exchanger consists of six identical stainless steel tubes connected in parallel as shown in the following figure. 假設每一根 tube 均為實心, 長度L, 直徑D. 其配置如下圖右, 離中心R的位置. 不鏽鋼之楊氏係數為E, 波桑比為ν. **試推導其 Torsional Stiffness** as your best.



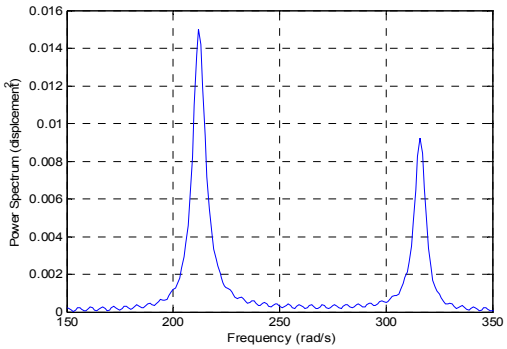
Problem 6. (10 Pts)

If the ground in the following figure, is subjected to a horizontal harmonic displacement with frequency ω= 200 rad/s and amplitude X_g= 15mm. **Please find the amplitude of vibration of the floor (mass m)**. Assume the mass of the floor as 2000 kg and the stiffness of the columns as 0.5 ×10^6N/m.



Problem 7. (10 Pts)

a. A typical portion of the power spectrum of a structural test is shown in below. Please estimate the damping ratios associated with the two modes. Note: this is a power spectrum plot, which means that the y-axis value is proportional to the square of vibration amplitude. (5 Pts)



b. If an optical table with mass of 200 Kg and is designed to attenuate base vibration for signal over 2 Hz. Please determine the static deflection of the optical table if one places 10Kg deadweight. (5 Pts)

Problem 8. (10 Pts)

In the following figure, a periodic force $F(t)=F_0\cos\omega t$ is applied at a point on the spring that is located at a distance of 25 percent of its length from the fixed support. Please find the steady-state response of the mass *m*.