國立成功大學機械工程學系

機械振動學(Mechanical Vibrations)

Spring Term 2023

QUIZ III

June 13 2023 (Tuesday)　　15:10 – 17:10 PM (不延長)　　RM. 91302

Note:

An A4 sheet of notes is permissible (請不要在 handout 上面黏貼其它的資料)

共 5 大題.　本次題目 (含此頁) 計 4 頁　　Total 121 Points

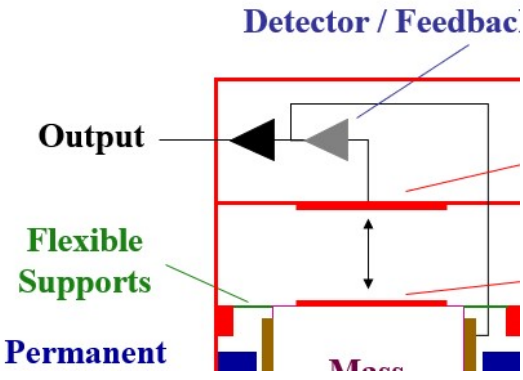
Problem 1. Key Concepts (35 Pts: 5 each)

A. What are principal coordinates? Please use both mathematics and physics/engineering to explain its characteristics.

B. In class, we have briefly explained the orthogonality between mode shapes (i.e., eigenvectors). Based on such a property, a series of mathematical operation could be performed to achieve subsequent computational analysis of vibration. Please try to use your words to explain such an aspect.

C. 在課堂上 (Ch. 6) 我們提到了 inertia coefficient 方法, 藉由該方法探求系統的 mass matrix. 請用自己的話, 配合力學與數學, 說明該方法.

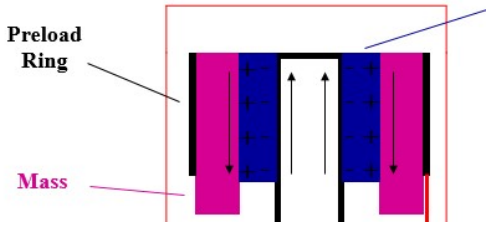
D. 在實驗振動力學部分, 我們介紹了如下圖所示之 force-feedback accelerometer, 請以自己的話, 說明該感測器之工作原理.



E. Would you please use your words to outline the solution procedure of Lagrange equation approach for vibrational analysis?

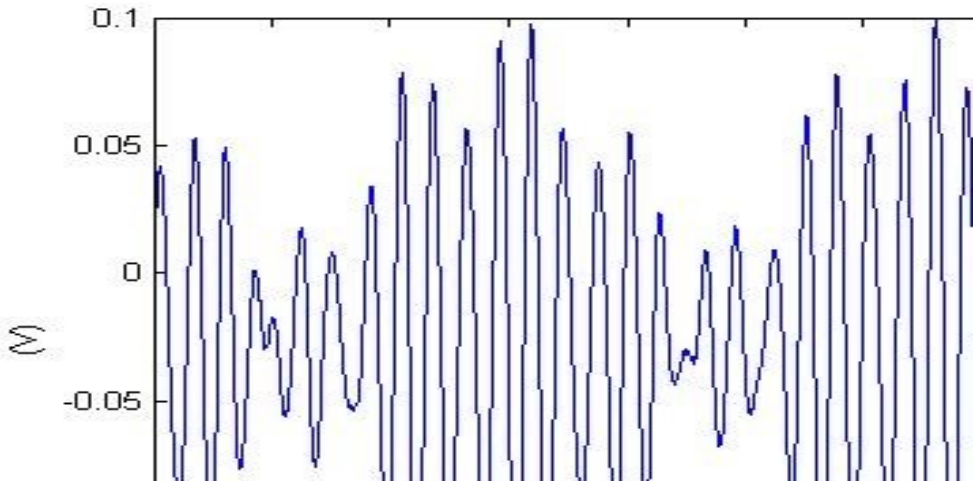
F. 請以自己的話, 說明 Swept Sine 測試的大概過程.

G. 請說明如下圖所示之 shear type piezoelectric accelerometer 之工作原理



Problem 2. 實驗振動力學 (25 Pts)

A. 下圖為過去我們測試成功大學校鐘的振動響應. 請由圖的數據大略估計其振動頻率 (橫軸單位為秒). Notes: it may have **more than ONE** natural frequencies (5 Pts)



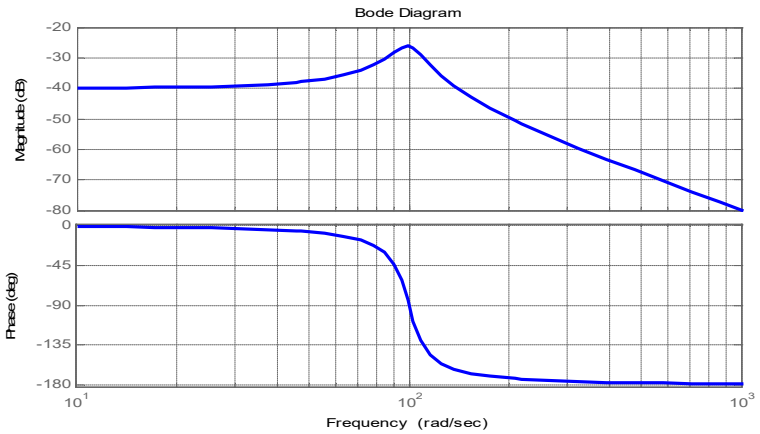
B. 光學桌是實驗室內常用到的隔振設備. 其主體結構可分為桌面與桌腳兩大部分. 請說明每一部分之在隔振上之主要功能與設計原則. 另外, 若你的光學桌的設計目標是讓頻率在 2 Hz 以上之地面振動被衰減掉, 假設光學桌重 200 Kg, 則請問該光學桌在受垂直方向 10N 力量下, 可能會有多大的垂直方向 deflection ? (9 Pts)

C. 若一個加速規之轉移函數被定為加速規輸出之訊號除上輸入之加速度 (即每單位加速度輸入可產生的電壓輸出). 典型之轉移函數如下圖所示: 請以該圖為基準, 回答下列問題: (6 Pts)

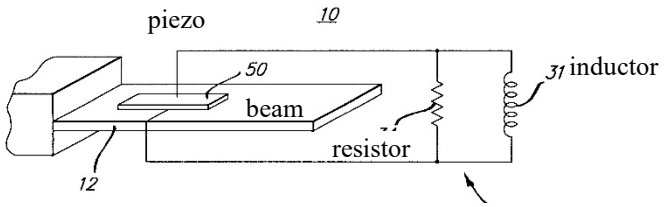
1. 請問該加速規之可操作頻率範圍與靈敏度, 並說明理由

2. 假設若要量測地震, 其靈敏度必須提昇 10 倍. 請問你如何在設計上修正? (僅限改變 m 與 k) 反之, 若要量

測汽車衝擊引發之振動，其頻寬必須要提升五倍，請問你如何在設計上修正? (僅限改變 m and k)

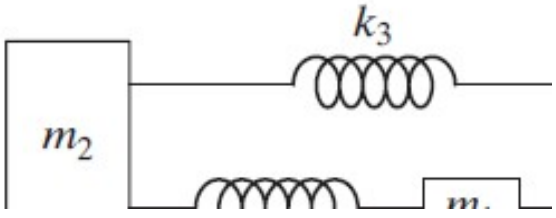


D. Please state the working principle of shear damper 或是 shunt piezo damper (see below). 上述兩種 damper 挑一種說明即可. 不要全寫，否則寫錯的部分當成是你的"一定"選項. 或許需要畫出額外的圖說明之. **(5 Pts)**



Problem 3. MDOF Vibration (20 Pts)

Please find the stiffness matrix (10 Pts) and flexibility matrix (10 Pts) of the following system. You are asked to find both of them by the method described in class (not just find one of them and then perform matrix inverse). If you just inverse one matrix to obtain the other one, that part would have no credits.



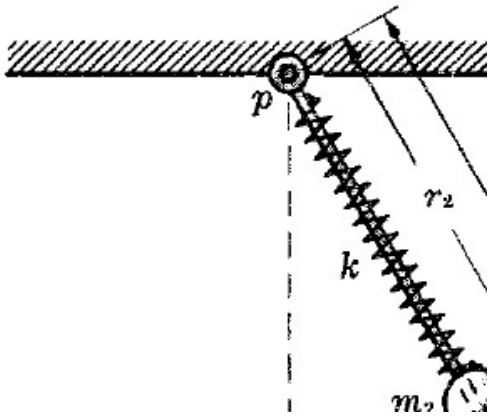
Problem 4. Lagrange's Equation (16 Pts)

Consider the system shown below. The light (mass could be neglected) rigid rod supporting the particle mass m_1 is pivoted at p so that it is free to rotate in a vertical plane under the action of gravity. The bead of mass m_2 is free to slide along the smooth rod under the action of gravity and

the spring. The unstretched length of the spring is l_0. Please use r_1, r_2, and θ as the generalized coordinate to answer the following questions.

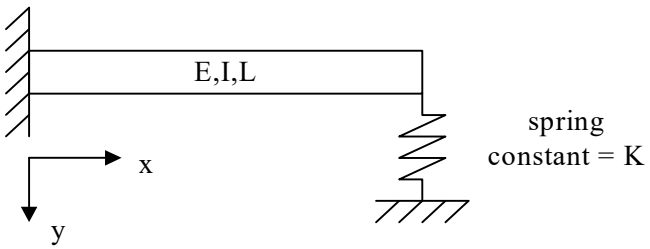
(a) Please find the kinetic and potential energies of the system. (8 Pts)

(b) Please find the equation of the system. (8 Pts)

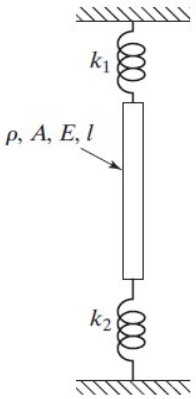


Problem 5. Continuous Vibrations (25 Pts)

A. 樑之振動可以由 $EI\dfrac{\partial^4 y(x,t)}{\partial x^4}-\rho\dfrac{\partial^2 y(x,t)}{\partial t^2}=F(x,t)$ 表示. 但若欲解該方程式必須要有正確的邊界條件. 請列出 free-free beam 及下圖樑的正確邊界條件. (請以數學式子表示). (5 Pts)



B. Consider the **bar** shown below. Please find its corresponding frequency equation. (12 Pts)



C. The cord of a musical instrument is fixed at both ends and has a length 2 m, diameter 0.5 mm, and density 7800 Kg/m^3. Find the tension required in order to have a fundamental frequency of 1 Hz. (8 Pts)