

國立成功大學機械工程學系

分析動力學 Fall Term 2020

QUIZ III

Jun. 24 2020 (Wednesday)

6:30 AM – 8:30 PM (can be extended to 9:00 PM)

RM. 91203

共 5 題

Note: A4 sheet of notes is permissible

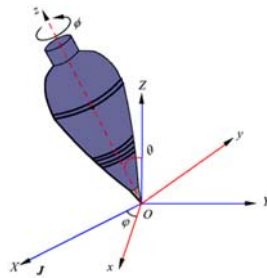
Total 117 Points

Problem 1. Concepts (total 50 Points, 每題 5 分)

1. 鋼的楊氏係數 200 GPa, 密度 7800 Kg/m³, 鋁則是 70 GPa 以及 2700 Kg/m³ 若聲音在一根鋼桿內傳播的速度為 c , 請問將此鋼桿換成鋁桿後, 其聲音傳播的速度有何變化.
2. In order to describe vibration in continuous systems, boundary conditions must be obtained. There are two types of boundary conditions in view of energy approach. Please describe them and state the key characteristics.
3. 請說明 Modal superposition (i.e., Modal decomposition) 此種振動分析方法之流程, 其理論根據, 以及其物理意義.
4. 就您的認知, angular momentum vector 與 angular velocity vector 同一方向的條件是甚麼? 如果二者不同方向, 可能會引發那些問題?
5. 如下圖, 一個高速自旋的腳踏車輪子, 受重力影響下, 導致輪子順時針公轉. 試說明此一現象.



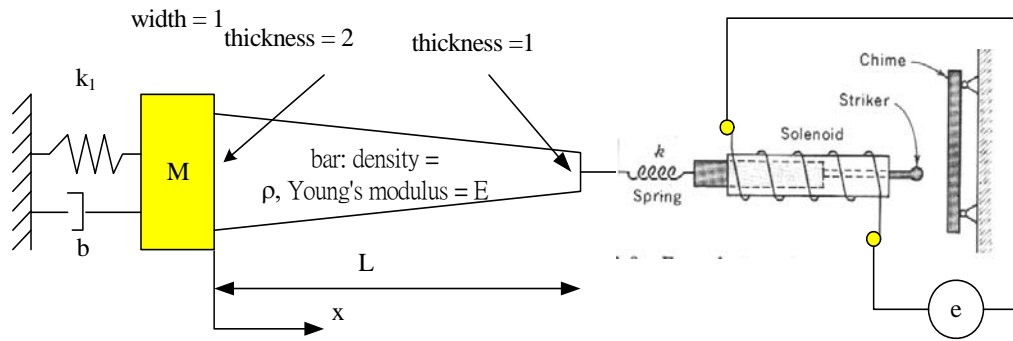
6. 就你的觀察, 描述一個 3D 旋轉物體之運動, 使用 global 與 body-fixed coordinates 各有哪些困難? 若是使用 Euler angle expression, 則可能帶來哪些便利與麻煩?
7. 請畫出一典型的連續結構振動頻域響應圖以說明何謂 resonance 與 anti-resonance 頻率. 我們如何以實驗方式求取這些頻率?
8. 在 3D 剛體動力學上, 我們主要探討的是底下的 symmetric top 問題. 為了描述它的運動, 我們引入了 Euler Angles. 請問用 Euler angles 來描述該物體之運動有何優勢 (或是如果不用 Euler angles, 則在問題描述上會有何窒礙難行的地方)



9. 在連續系統振動問題上, 請說明節點的物理意義. 許多 free-free beam 實驗, 均把支撐點放於節點上, 為什麼?
10. 請定義 Polhode. 並請以它說明剛體旋轉之穩定性問題.

Problem 2 Continuous Vibration (15 Pts)

- (a) Please find the potential, kinetic, and magnetic energy of the system (5 Pts)
- (b) Please write the extended Hamilton's principle for the system (5 Pts)
- (c) Using any methods, please find the equation of motion of the bar and the door chime. (5 Pts) 注意: 本小題不可能在考試時間內用任何正規的推導方式獲得精確的 equation, 但是可以用物理的方式, 寫出大略的運動方程式.



Problem 3. Continuous Vibration (20 Pts)

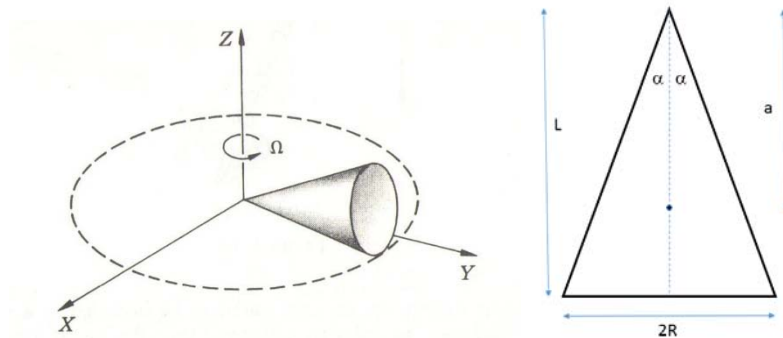
Consider a simply supported beam (Length = l , cross-sectional area = A , density = ρ , material Young's modulus E) under transverse vibration.

- Please write down the equation and the associated boundary conditions. (you don't need to derive the equation here. Just state the results carefully). (5 Pts)
- Please find the frequency equation and the associated natural frequencies. (9 Pts)
- Find the cross-sectional area (A) and the area moment of inertia (I) of a simply supported steel beam of length 1 m for which the first three natural frequencies lie in the range 1500 - 5000 Hz. (6 Pts) (if Square cross section)

Problem 4. 3D Rigid Body Dynamics (15 Pts)

A rigid cone with apex half angle α rolls steadily without slip on a horizontal surface so that it rotate about Z axis at a constant angular rate Ω . The cone has a mass M and principal moments of inertia I_1, I_1 and I_3 at the tip and the distance between the tip and the center of mass is a .

- Please show that the amount of the angular velocity of the cone $\omega = \Omega \cot \alpha$. (6 Pts)
- Please find the kinetic energy of the cone. (9 Pts)



Problem 5. 3D Rigid Body Dynamics II (17 Pts)

A table with axial moment of inertia I can turn in fixed bearings without friction. The table carries a *massless* rigid frame from which is suspended a *massless* pendulum arm carrying a spinning disk. The disk has mass M and principal moments of inertia I_1, I_2 , and I_3 at the centroid.

- A. Select generalized coordinates to describe the motion of the table and the disk. Please label them clearly. (4 Pts)
- B. Please find the kinetic energy of the system. (8 Pts)
- C. Formulate equations of motions, including the effects of gravity but neglecting friction. (5 Pts)

