注意：考試開始鈴響前，不得翻閱試題，
並不得書寫、畫記、作答。

國立清華大學 111 學年度碩士班考試入學試題

系所班組別：動力機械工程學系
丙組(固體與奈微米力學組)

科 目 代 碼 ：1301

考 試 科 目 ：材料力學

—作答注意事項—

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 考試開始後，請於作答前先翻閱整份試題，是否有污損或試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

國立清華大學 111 學年度碩士班考試入學試題

系所班組別：動機系 丙組

考試科目（代碼）：材料力學 (1301)

　　*請在【答案卷、卡】作答

1. **[15 Points]** For a 3-D structure formed by a beam with circular cross-section shown in Fig. 1, calculate the deflection of point B in the direction of the applied force F_z (neglect the effect of bending shear). Noted that $\overline{BC}$, $\overline{AC}$, and $\overline{OA}$ are perpendicular to each other. F_z is along Z-direction.

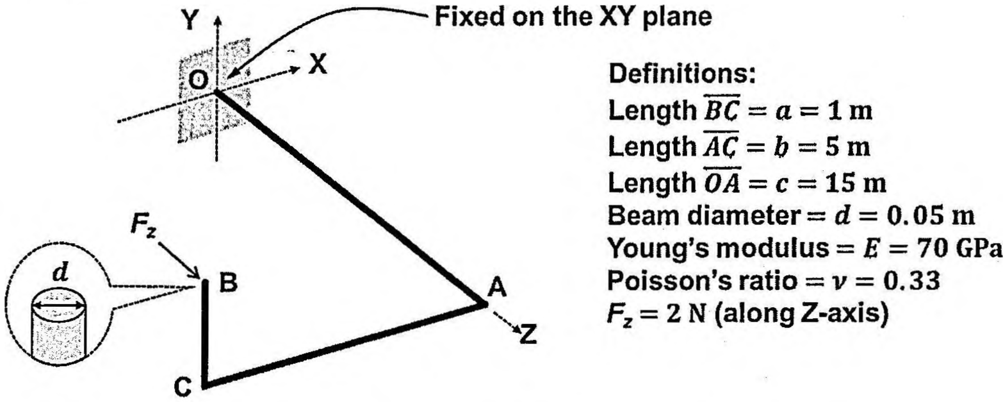

Fig. 1. The mock-up view of the 3-D structure.

2. **[15 Points]** When a hoisting cable (cross-sectional area $= A$ and Young's modulus $= E$) is long, the weight of the cable itself contributes to the elongation. If a cable has a weight per unit length of w, a length of L, and a load P attached to the free end, determine the cable elongation (δ).

3. **[18 Points]** A laminated plastic beam of square cross section is built up by gluing together three strips, each 10 mm $\times$ 30 mm in cross section, as shown in Fig. 2. The beam has a total weight of 3.2 N and is simply supported with span length $L = 320$ mm. Considering the weight of the beam, calculate the maximum permissible load P that may be placed at the midpoint if (a) the allowable shear stress in the glued joints is 0.3 MPa, and (b) the allowable bending stress in the plastic is 8 MPa.

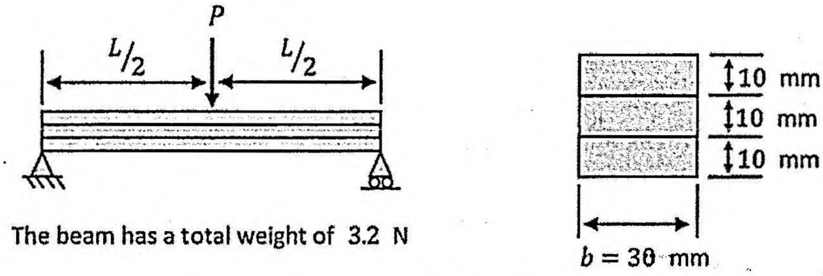

Fig. 2. The laminated plastic beam.

4. **[17 Points]** A long, thin-walled tapered tube AB of circular cross section is subjected to a torque T, as shown in Fig. 3. The tube has length L and constant wall thickness t. The diameter to the median lines of the cross sections at the ends A and B are d_A and d_B, respectively. The shear modulus is G. (a) Find the angle of twist of end A with respect to end B. (b) Determine the strain energy U.

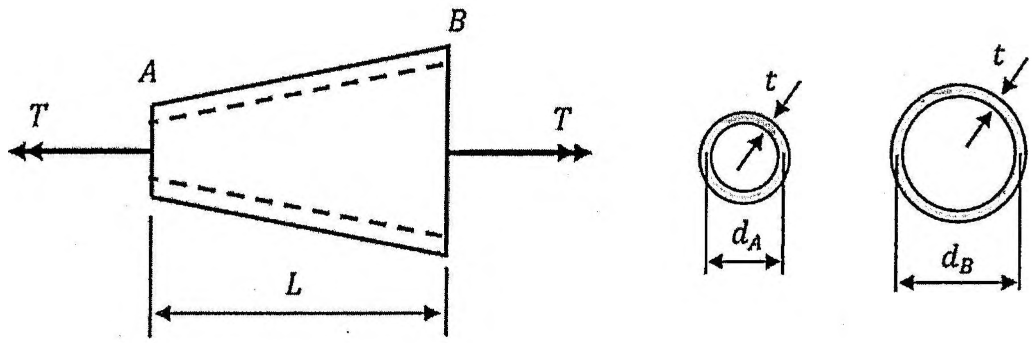

Fig. 3. The tapered tube.

5. **[20 Points]** A beam with $L = 2$ m, Young's modulus E, and moment of inertia I, is subjected to a uniform load $w = 1$ kN/m as shown in Fig. 4. Use $EI = 1$ for the computation (omit their unit). Consider reaction R_B at point B as a redundant force, and answer the following questions:
   (a) Obtain the flexural strain energy in terms of R_B.
   (b) Obtain R_B using **Castigliano's theorem**.
   (c) Obtain the rotational angle θ_B at point B using **Castigliano's theorem**.
   (d) Obtain the rotational angle θ_B at point B using **Unit load method**.

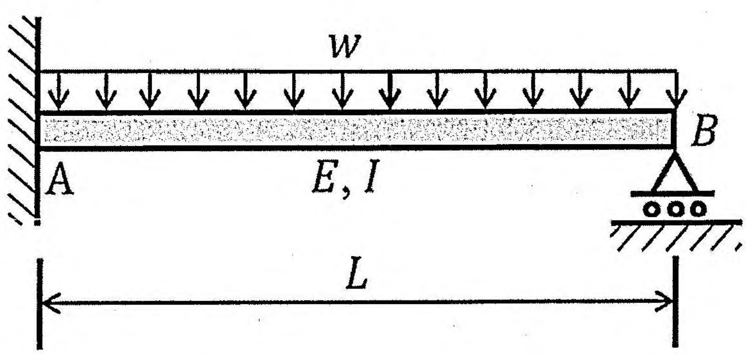

Fig. 4. Beam subjected to uniformly distributed load

6. **[15 Points]** As expressed in Fig. 5, a brass pipe having the cross-section shown has an axial load P applied e mm from its geometric axis (eccentric load). Using $E = 120$ GPa, and neglecting the slope effect, answer the following questions:
   (a) **Derive** the equation of the deflection curve (also known as Secant Formula) for the column. (Hint: the result is $v(x) = e\left[\tan\left(\frac{\lambda L}{2}\right)\sin(\lambda x) + \cos(\lambda x) - 1\right]$, where $\lambda = \sqrt{\frac{P}{EI}}$)
   (b) If $e = 5$, determine the load P for which the horizontal deflection at the midpoint C is 5 mm and determine the corresponding maximum stress in the column.

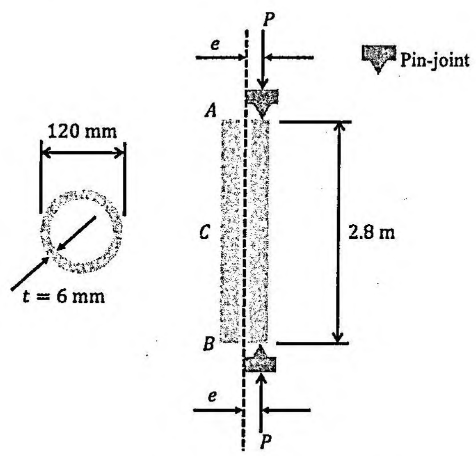

Fig. 5. An elastic column subjected to loads on both ends.

Appendix: Table of integrals

$$\int \frac{dx}{x^n} = \frac{x^{1-n}}{1-n} \quad (n \neq 1) \qquad \int (a+bx)^n\,dx = \frac{(a+bx)^{n+1}}{b(n+1)} \quad (n \neq -1)$$

$$\int \frac{dx}{a+bx} = \frac{1}{b}\ln(a+bx) \qquad \int \frac{dx}{(a+bx)^2} = -\frac{1}{b(a+bx)}$$

$$\int \frac{dx}{(a+bx)^n} = -\frac{1}{(n-1)(b)(a+bx)^{n-1}} \quad (n \neq 1)$$

$$\int \frac{dx}{a^2+b^2x^2} = \frac{1}{ab}\tan^{-1}\frac{bx}{a} \quad (x \text{ in radians}) \quad (a>0, b>0)$$

$$\int \frac{dx}{a^2-b^2x^2} = \frac{1}{2ab}\ln\left(\frac{a+bx}{a-bx}\right) \quad (x \text{ in radians}) \quad (a>0, b>0)$$

$$\int \frac{x\,dx}{a+bx} = \frac{1}{b^2}[bx - a\ln(a+bx)] \qquad \int \frac{x\,dx}{(a+bx)^2} = \frac{1}{b^2}\left[\frac{a}{a+bx} + \ln(a+bx)\right]$$