國立臺灣科技大學 108 學年度碩士班招生試題
系所組別：機械工程系碩士班甲組
科　　目：材料力學

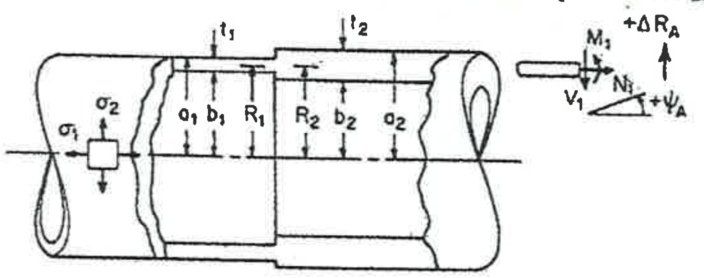
(總分為 100 分)

1. Two cylindrical shells of different thickness are subjected to an internal pressure loading. Please find the radial deflection of the common circumference between the two shells. (25 分) The formulas are provided in the following table.
In this problem,
- Thickness of the larger outside diameter cylinder, t_2, is 2 inches
- Thickness of the smaller outside diameter cylinder, t_1, is 1 inch
- Modulus of Elasticity (same for both cylinders) is 3×10^7 psi
- Inner Radius (same for both cylinders) is 19.5 inches
- Radius to midplane of the small cylinder, R_1, is 20 inches
- Poisson's ratio (same for both cylinders) is 0.3
- Internal pressure is 100 psi

Formulas for discontinuity stresses and deformations at the junctions of shells and plates

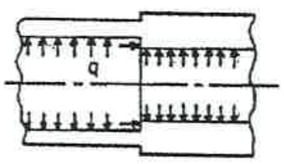
NOTATION: R_A = radius of common circumference; ΔR_A is the radial deflection of the common circumference, positive outward; ψ_A is the rotation of the meridian at the common circumference, positive as indicated. The notation used in Tables 11.2 and 13.1–13.3 is retained where possible with added subscripts 1 and 2 used for left and right members, respectively, when needed for clarification. There are some exceptions in using the notation from the other tables when differences occur from one table to another

1. Cylindrical shell connected to another cylindrical shell. Expressions are accurate if $R/t > 5$. E_1 and E_2 are the moduli of elasticity and ν_1 and ν_2 the Poisson's ratios for the left and right cylinders, respectively. See Table 13.2 for formulas for D_1 and λ_1. $R_A = R_1$, $b_1 = R_1 - t_1/2$, and $a_1 = R_1 + t_1/2$. Similar expressions hold for b_2, a_2, D_2, and λ_2.



Loading and case no.

1a. Internal* pressure q



Note: There is no axial load on the left cylinder. A small axial load on the right cylinder balances any axial pressure on the joint. For an enclosed pressure vessel superpose an axial load $P = q\pi b_1^2$ using case 1b.

Load terms

$$LT_{A1} = \frac{b_1 R_1}{t_1^2}$$

$$LT_{A2} = \frac{-b_2 R_2 E_1}{E_2 t_1 t_2}$$

$$LT_{AC} = \frac{E_1(b_1^2 - b_2^2)}{8t_1}\left(\frac{a_2 - b_1}{R_2 D_2 \lambda_2^2} - \frac{4\nu_2}{E_2 t_2}\right)$$

$$LT_{B1} = 0, \qquad LT_{B2} = 0$$

$$LT_{BC} = E_1(b_1^2 - b_2^2)\frac{a_2 - b_1}{4R_2 D_2 \lambda_2}$$

At the junction of the two cylinders,

$$V_1 = qt_1 K_{V1}, \qquad M_1 = qt_1^2 K_{M1}, \qquad N_1 = 0$$

$$\Delta R_A = \frac{qt_1}{E_1}(LT_{A1} - K_{V1}C_{AA1} - K_{M1}C_{AB1})$$

$$\psi_A = \frac{q}{E_1}(K_{V1}C_{AB1} + K_{M1}C_{BB1})$$

Selected values

For internal pressure, $b_1 = b_2$ (smooth internal wall), $E_1 = E_2$, $\nu_1 = \nu_2 = 0.3$, and for $R/t > 5$.

$$\Delta R_A = \frac{qR_1^2}{E_1 t_1} K_{\Delta RA}, \qquad \psi_A = \frac{qR_1}{E_1 t_1} K_{\psi A}, \qquad \sigma_2 = \frac{qR_1}{t_1} K_{\sigma 2}$$

	$\frac{t_2}{t_1}$	R_1/t_1					
		10	15	20	30	50	100
K_{V1}	1.1	0.0542	0.0688	0.0808	0.1007	0.1318	0.1884
	1.2	0.1066	0.1353	0.1589	0.1981	0.2593	0.3705
	1.5	0.2574	0.3269	0.3843	0.4791	0.6273	0.8966
	2.0	0.4945	0.6286	0.7392	0.9220	1.2076	1.7264
	3.0		1.1351	1.3356	1.6667	2.1840	3.1231
K_{M1}	1.1	0.0065	0.0101	0.0137	0.0208	0.0352	0.0711
	1.2	0.0246	0.0382	0.0518	0.0790	0.1334	0.2695
	1.5	0.1295	0.2012	0.2730	0.4166	0.7038	1.4221
	2.0	0.3891	0.6050	0.8211	1.2535	2.1186	4.2815
	3.0		1.4312	1.9436	2.9691	5.0207	10.1505
$K_{\Delta RA}$	1.1	0.9080	0.9232	0.9308	0.9383	0.9444	0.9489
	1.2	0.8715	0.8853	0.8922	0.8991	0.9046	0.9087
	1.5	0.7835	0.7940	0.7992	0.8043	0.8084	0.8115
	2.0	0.6765	0.6827	0.6857	0.6887	0.6910	0.6927
	3.0		0.5285	0.5283	0.5281	0.5278	0.5275
$K_{\psi A}$	1.1	−0.1618	−0.2053	−0.2412	−0.3006	−0.3934	−0.5620
	1.2	−0.2862	−0.3633	−0.4269	−0.5321	−0.6965	−0.9952
	1.5	−0.5028	−0.6390	−0.7515	−0.9372	−1.2275	−1.7547
	2.0	−0.5889	−0.7501	−0.8831	−1.1026	−1.4454	−2.0676
	3.0		−0.6118	−0.7216	−0.9026	−1.1850	−1.6971

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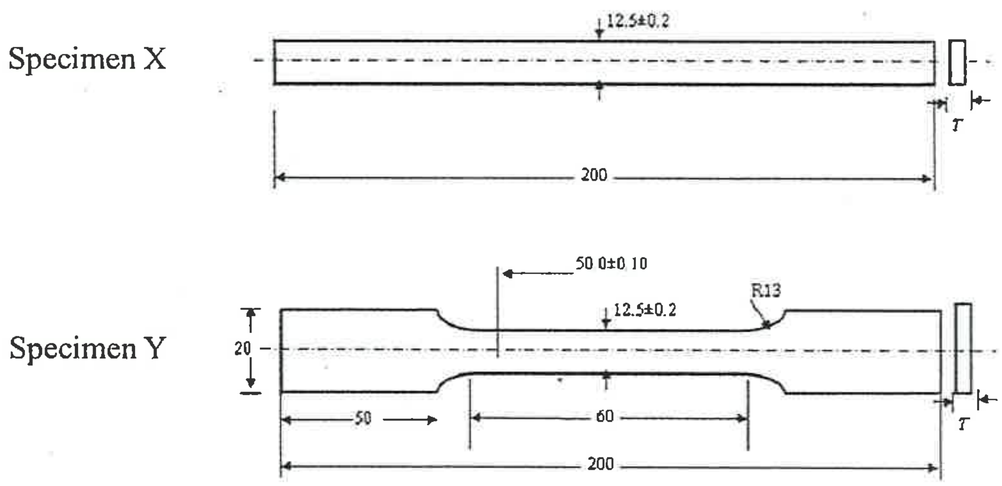
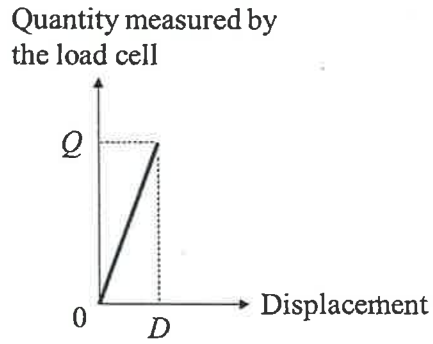
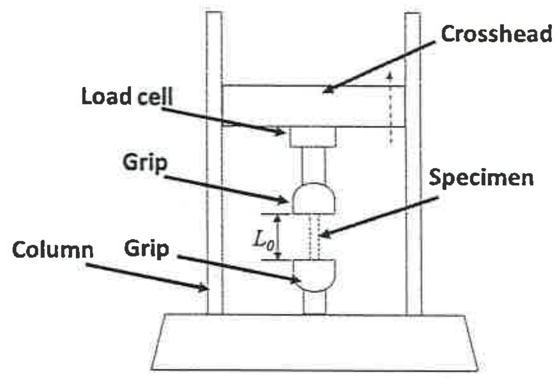
(總分為 100 分)

2. A desktop universal testing machine is shown in the following figure on the left. During the tensile test within the elastic range, the crosshead moved up to pull the specimen, and the displacement, D, of the crosshead was recorded. At the same time, the physical quantity Q that the load cell measured was also recorded. When the test started, the initial displacement D was zero, and the initial length of the specimen between the two grips was L_0 ($L_0 > 120$ mm). The displacement D gradually increased from zero until the test ended when the specimen was about to have permanent plastic deformation. Only the two quantities, D and Q, were recorded in the tensile test, and their relationship could be seen in the figure below. Two sheet metal specimens, Specimen X and Specimen Y, were made according to the dimensions shown in the following figure on the right. Both had the same thickness T. Specimen X had a uniform width of 12.5 mm throughout its length, and Specimen Y had a uniform width of 12.5 mm in the middle portion and a uniform width of 20 mm at both ends.



Unit: mm





(a) What does the load cell measure? (5 分)

(b) What is the unit of strain? (5 分)

(c) Please describe how to obtain the Young's modulus for the specimens used in the tensile test. There is no need to discuss the unit of the Young's modulus here. (5 分)

(d) Which specimen, Specimen X or Specimen Y, can be used to obtain more accurate Young's modulus under the condition described in the problem? Why? No explanation will receive zero points. (5 分)

(e) Why is the type of Specimen Y, not the type of Specimen X, the most common design of the tensile test specimen for sheet metal? (5 分)

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3. 簡答題 (共 25 分) [寫出答案即可，無需寫出過程]

(1) Which of the following items are zero in both **Plane stress** and **Plane strain** conditions in the xy plane? (5 分) (複選，需答案全對才得分)

(a) τ_{xy}　(b) γ_{yz}　(c) τ_{xz}

(d) ε_{y}　(e) σ_{z}　(f) γ_{xz}

(2) About strain energy, which ones are true? (5 分) (複選，需答案全對才得分)

(a) The strain energy is equal to the work done by the load if no energy is added or subtracted in the form of heat.

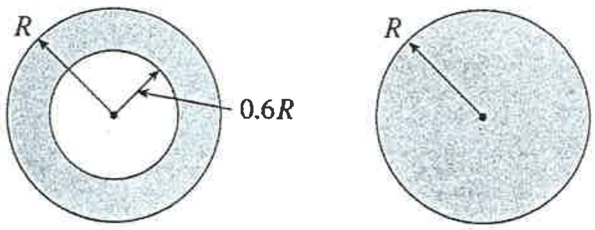
(b) The strain energy of a structure supporting more than one load can be obtained by adding the strain energies obtained for the individual loads acting separately.

(c) The strain energy recovered during unloading is called the elastic strain energy.

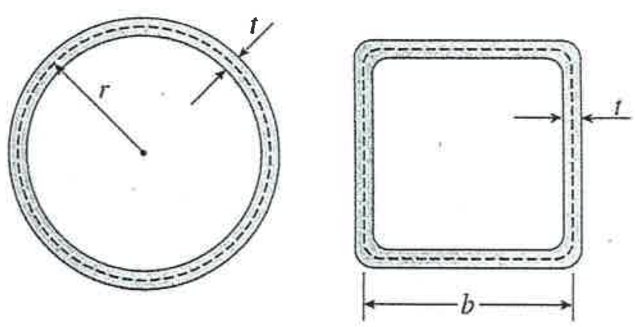
(d) When the material is linearly elastic, strain energy is a linear function of loads.

(e) In most beams, in which the lengths are much greater than the depths, the strain energy of shear may be disregarded.

(3) A hollow shaft and a solid shaft, constructed of the same material, have the same length and the same outer radius R. The inner radius of the hollow shaft is 0.6R. Which one has greater strength-to-weight ratio? (5 分)



(4) A circular tube and a square tube are constructed of the same material and subjected to the same torque. Both tubes have the same length, same wall thickness, and same cross-sectional area. Which one has a greater stiffness against rotation? (5 分)



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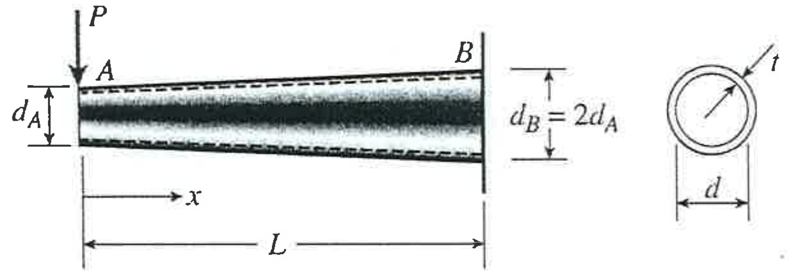
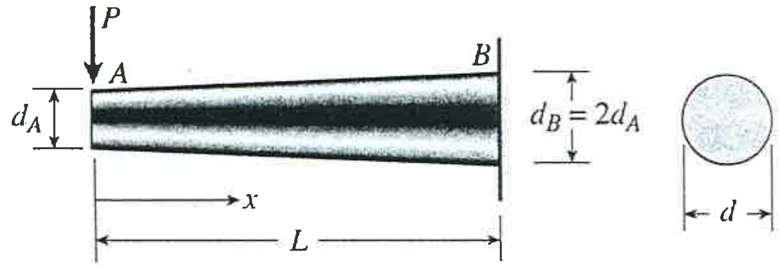
(5) Defection at the end A of the beam in the following cases, which one is larger? (5 分)

(a)



(b)



4. A cantilever beam OA of span length $L=9\ m$ is loaded by a uniform load of intensity $q = 4\ kN/m$ and a concentrated load $P = 6\ kN$ (see figure). The concentrated load acts at a point $L/3$ from the left-hand end of the beam. The beam has a circular cross-section of $d = 150\ mm$.

(1) Draw the shear-force and bending-moment diagrams for this beam. (15 分)

(2) Determine the maximum tensile stress in the beam due to bending. (10 分)