University of Nottingham
Department of Mechanical Engineering

MMME2053 Mechanics of Solids
Exercise Sheet 9 – Elastic Instability (Buckling)

1. Find the critical load for a steel column of rectangular cross-section, 50mm by 25mm and of length 3m for each of the following assumptions:

    (a) Both ends are hinged
    (b) Both ends are built-in (fixed)
    (c) One end is hinged and the other end is built-in (fixed).

[Ans: a) 14.28kN, b) 57.12kN, c) 29.2kN]

2. By what factor would the cross-section dimensions of the beam in question 1 have to be increased to ensure the same critical load for condition (a) if the material were changed to Aluminium with a Young's modulus of 70GPa?

[Ans: 30%]

3. A new tripod for a surveying instrument will consist of three equal tubular legs, hinged at the top and resting on points at the bottom. When the instrument is set up for use, the top hinge points are equally spaced on a 100mm diameter horizontal circle, whilst the pointed ends are equally spaced on a 1m diameter horizontal circle. The top hinge points are 1.3m above the level ground on which the point ends rest. The greatest expected instrument weight is 80N. Assuming a factor of safety of 10 against elastic buckling, select the lightest safe Aluminium tube (E = 70GPa) from the following stock list (Table 3.1).

Table 3.1

Thickness (mm)	Outer diameters available (mm)
1	5, 10, 15, 20, 25, 30
2	10, 15, 20, 25, 30, 40
3	15, 20, 25, 30, 40, 50

[Ans: t=1mm & OD=15mm]

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4. A hollow steel column, 9m long and of circular cross-section, 90mm outer diameter and 75mm inner diameter is subjected to an end thrust of 30kN. The line of action of thrust is parallel to the unstrained line of a strut, but does not coincide with it. Under load the maximum deviation of the strut from the straight line is 80mm. Find (a) the eccentricity of the load and (b) the maximum compressive and tensile stresses. The ends may be assumed to be hinged.

[Ans: a) 22.49mm, b) -98.41MPa & 67.55MPa]

5. A steel strut with hinged ends, length 1.5m and cross-section 25mm by 25mm square, is found to be curved before applying a load. The curvature can be represented by

$$y_o = 5sin\left(\frac{2\pi x}{3}\right) mm$$

where y_o is the distance of a point on the axis of the strut in the unloaded state from the line of action of the loads which act through the hinge points, and xm is the distance of this point from one end of the strut. Find the maximum compressive stress if the loading is 15kN.

[Ans: -84.66MPa]