

**OLLSCOIL NA hÉIREANN, GAILLIMH**  
**NATIONAL UNIVERSITY OF IRELAND, GALWAY**

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**WINTER EXAMINATIONS, 2000**  
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**B.E. DEGREE EXAMINATION**

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**INELASTIC STRUCTURAL ANALYSIS**

Professor R. A. Falconer;  
Professor P. E. O'Donoghue;  
Dr. P. Ó hEachteirn.

Time allowed : *Two* hours

Answer *Two* questions

**NOTE**

The use of an electronic calculator is allowed.

### Question 1

- (a) Figure Q1 shows a prismatic beam with fully fixed end supports (*encasté*), subject to the factored loading shown. It is also fully restrained laterally. This beam is made from a linear-elastic-perfectly-plastic material with  $M_p = 375 \text{ kNm}$ . Analyse the beam on a step-by-step hinge-by-hinge basis and plot (and annotate) the load-deflection history to collapse. The material elastic modulus is  $E$ , and the second moment of area is  $I$ .
- (b) Summarize, in tabular format, the progression of the bending moment diagram from the elastic stage to the ultimate collapse bending moment diagram.

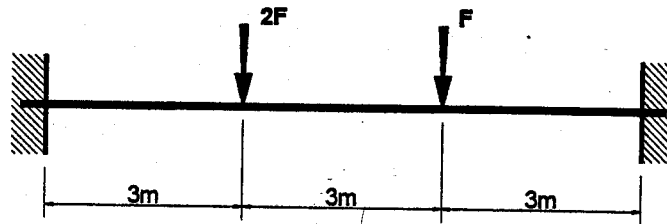


Figure Q1

### Question 2

- (a) Derive, from first principles, an expression for the partially-plastic moment of resistance of a beam,  $M_p$ , of a linear-elastic perfectly-plastic material. The beam is rectangular in cross-section.
- (b) Sketch your expression in a graph of  $M_p$  versus  $\epsilon$ , the extreme fibre strain.
- (c) Sketch a modified stress block which includes the effects of strain hardening. Assume that a maximum strain hardening stress of  $0.5\sigma_y$  is achieved. From this modified stress block, estimate approximately the extra ultimate plastic moment of resistance of a beam due to the effects of strain hardening.
- (d) Sketch moment-rotation curves of beams of the following cross-sectional shapes, assuming a constant stiffness for the linear elastic portion of the curves: I-section, Circular tube, Rectangular tube, Rectangular solid, Diamond solid, Triangular solid.

### Question 3

- (a) Figure Q3 shows a pitched portal frame, which is of uniform cross-section throughout with a plastic moment of resistance of  $M_{pl} = 800 \text{ kNm}$  and which has pinjointed feet. Find the value of  $H$ , which causes ultimate plastic collapse of the frame.
- (b) Calculate and draw the corresponding ultimate plastic collapse bending moment diagram.

