ENG2002 Winter 2011 Test 2

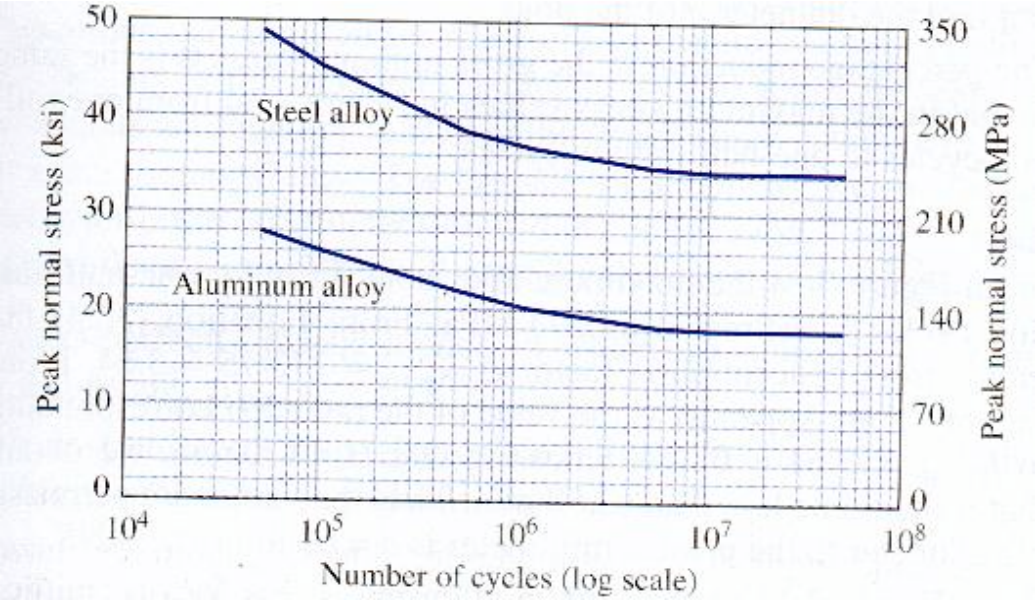
Richard Hornsey 1 hour
17 February 2011 Calculators may be used
Marks for each question are shown; 50 in total

1. What is meant by fatigue in a material and why is it important in engineering materials? Describe the two broad categories of fatigue behaviour. [6]

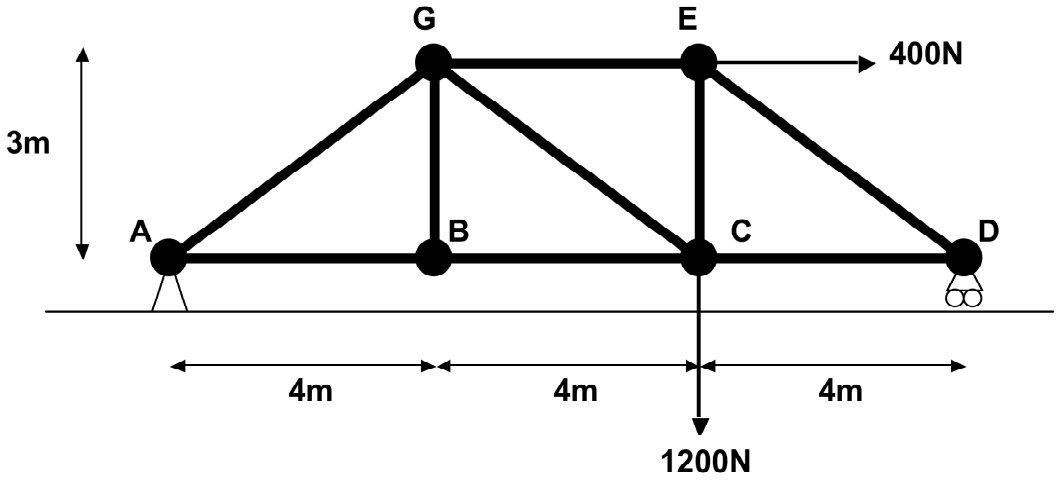
2. An 80kg person bungie-jumps from a rope supported from a hook made from a cylindrical steel bar. Use the fatigue characteristic below to determine the diameter of the bar required so that the bar fails only after 5 million jumps (assume 5 bounces per jump). $E_{steel} = 207$ GPa. [10]

3. Explain Griffith's theory of crack propagation and suggest why the effect of cracks is different in ductile and brittle materials. [4]

4. If a crack of 20μm tip radius and 10μm depth exists in the surface of the hook above, what would now be the fatigue lifetime? [10]



5. Determine the forces in members GE, GC, and BC of the truss below and indicate whether they are in tension or compression. [20]



Question 1

Q4. Fatigue is failure due to repeated load/unload cycles in which the maximum stress is well below the strength of the material (4 Marks). Some materials reach a fatigue limit, while others continue to weaken with increasing number of cycles (2 Marks).

Question 2

$m = 80kg$, Cycles $= 5 \times 10^6 \times 5$ bounces/jump $= 2.5 \times 10^7$. At 2.5×10^7 Cycles, $\sigma_{max} \approx 240Mpa$.

$$\sigma_{max} = F/A = 4ma/(\pi d^2)$$

$$d = (4ma/(\pi\sigma_{max}))^{0.5} = \left(4(80)(9.81)/(\pi(240 \times 10^6)\right)^{0.5} = 0.002m = 2mm$$

Question 3

From notes.

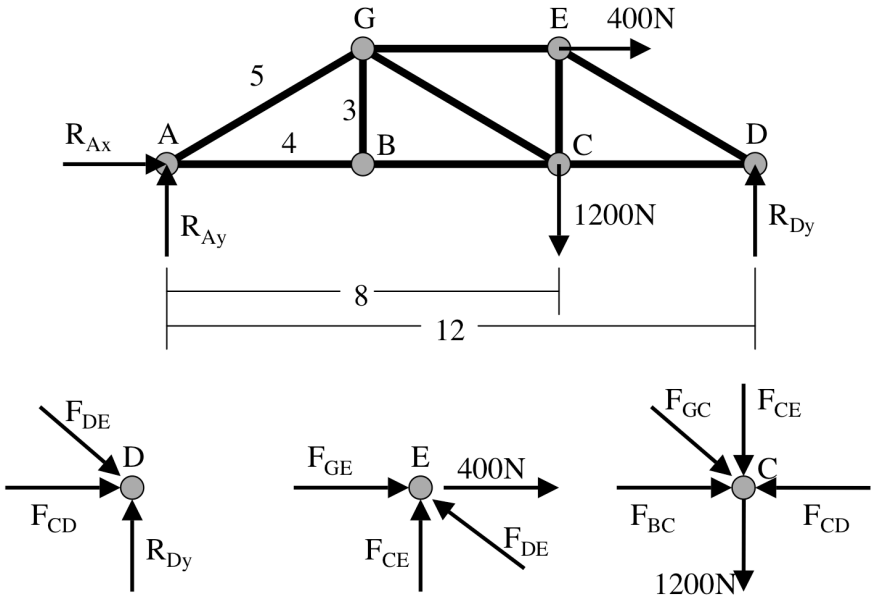
Question 4

$$\sigma_m = 2\sigma_o(a/\rho_t)^{1/2} = 2(240 \times 10^6)(10 \times 10^{-6}/20 \times 10^{-6})^{1/2} = 340 \times 10^6 Pa.$$

From graph, $340MPa$ is reached at 6×10^4 cycles. (10 Marks)

Question 5

Q1. (Marks: 5 FBD, 5 Reaction Forces, 15 Point Analysis, 5 Correct Answers)



For whole structure (All units in N):

$$\Sigma M_A = 8(1200) + 3(400) - 12R_{Dy} = 0, \qquad R_{Dy} = 900$$

For point D:

$$\Sigma F_y = -3/5F_{DE} + R_{Dy} = 0, \qquad F_{DE} = 5/3(900) = 1500$$

$$\Sigma F_x = F_{CD} + 4/5F_{DE} = 0, \qquad F_{CD} = -4/5(1500) = -1200$$

For point E:

$$\Sigma F_x = F_{GE} + 400 - 4/5F_{DE} = 0, \qquad F_{GE} = 4/5(1500) - 400 = 800$$

$$\Sigma F_y = F_{CE} + 3/5F_{DE} = 0, \qquad F_{CE} = -3/5(1500) = -900$$

For point C:

$$\Sigma F_y = -3/5F_{GC} - F_{CE} - 1200 = 0, \qquad F_{GC} = -5/3(-900 + 1200) = -500$$

$$\Sigma F_x = F_{BC} + 4/5 F_{GC} - F_{CD} = 0, \qquad F_{BC} = -4/5(-500) + (-1200) = -800$$

Answer:

GE is 800N in compression. GC is 500N in tension. BC is 800N in tension.