SE104 Structural Materials
Sample Midterm Solutions

1. B
2. E
3. A
4. C
5. C
6. B
7. D
8. D
9. A
10. E
11. C
12. A
13. B
14. C
15. C
16. B
17. B
18. D
19. E
20. B
21. C
22. B
23. B
24. C
25. B
26. A
27. D
28. E

29. (a) Objective: To minimize the material cost

Objective Function: $C = mC_m = \rho ALC_m = ALC_v$

where C_V is the volumetric cost (cost per unit volume)

Constraints: Buckling strength must be higher than F^*, Height L specified

Constraint Function: $F* = \frac{n^2\pi^2 EI}{L^2}$, where E is the modulus of the material,

$I = \frac{\pi r^4}{4} = \frac{A^2}{4\pi}$ is the moment of inertia, L is the height of the rod, n is a constant depending on the boundary condition.

Free variables: Choice of material; cross-sectional area A.

By eliminating the free variable *A* from the objective function, we have

$$C = \sqrt{\frac{F*}{\pi}\frac{2L^2}{n}\frac{C_{v,R}}{\sqrt{E}}}$$

(b) The performance index is $C_{v,R}/\sqrt{E}$ or C_{VR}^2/E, which should be minimized; if the performance index is taken as E/C_{VR}^2 or $E^{1/2}/C_{VR}$, it should be maximized.

(c) The best choice of material is stone.

30. (a) Objective: Minimize the weight of the rod, (w)

Objective Function: $\theta = \frac{TL}{GK}$

Constraints: Twist Angle
Free variables: Choice of material, length of the rod

(b)

$$AL = m/\rho$$
$$L = m/\rho A$$

Substituting this into the objective function, we have

$$\theta = \frac{Tm}{\rho AGK}$$

$$i.e\ \ m = \frac{\theta \rho AGK}{T}$$

The performance index can be taken as ρG, which should be minimized.

(c) According to the chart the best choice of material would be glass fiber reinforced polymer (GFRP).

31. (a) Unit cell size of Cr, $a = \frac{4R}{\sqrt{3}} = \frac{4*0.128}{\sqrt{3}} = 0.295\ nm$

(b) Mass of a unit cell, $m = \frac{(2\ atoms)*\left(52\frac{g}{mol}\right)}{6.02*10^{23}\frac{atoms}{mol}}\left(10^{-6}\frac{Mg}{g}\right) = 1.728*10^{-28}\ Mg$

(c) Density $\rho = \frac{m}{V} = \frac{m}{a^3} = \frac{1.728*10^{-28}\ Mg}{(0.295)^3*10^{-27}\ m^3} = 6.73\ \frac{Mg}{m^3} = 6.73\ \frac{Mg}{cm^3}$

Bonus: (a) 60° (b) 12.5 MPa (c) No plastic deformation, since $\tau_r < \tau_y$