1. A Carnot refrigerator is maintaining foodstuffs in a refrigerator area at 40^0F by rejecting heat to the atmosphere at 80^0F. It is desired to maintain some frozen foods at 0^0F with the same sink temperature of 80^0F. What percentage increase in work input will be required for the frozen-food unit over the refrigerated unit for the same quantity of heat removed ? (10%)

2. Two pieces of copper, A and B, have masses of 1 and 3 kg and initial temperatures of 0 and 200^0C, respectively. They are brought into thermal contact and allowed to reach an equilibrium temperature while insulated from the surroundings. Determine the entropy change of each piece of copper, and check the increase-in-entropy principle for the process. (10%)

1. The steel block, as shown in Fig. 1, is subjected to a uniform pressure on (10%) all its faces. Knowing that the change in length of edge AB is -24 μm. Assume E = 200 GPa and ν = 0.29. Determine
   (a) the change in length of the other edges,
   (b) the pressure, p, applied to the faces of the block,
   (c) the change in volume, ΔV, of the steel block.

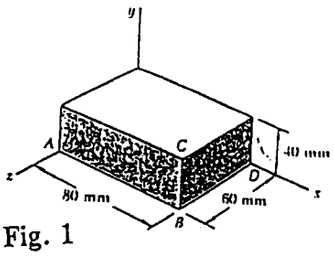

Fig. 1

2. Determine the longest unsupported length L for which the S 100x11.5 (10%) rolled-steel compression member AB can safely carry the centric load, as shown in Fig. 2. Assume σ_Y = 290 MPa and E = 200 GPa.

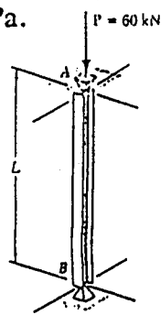

Fig. 2.

3. As shown in Fig. 3, the rigid bar BDE is supported by two links AB and (10%) CD. Link AB is made of aluminum of E = 70 GPa and has a cross-sectional area of 500 mm^2; Link CD is made of steel of E = 200 GPa and has a cross-sectional area of 600 mm^2. For the 30-kN force shown, determine the deflection of points B, D and E.

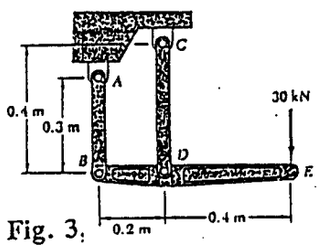

Fig. 3.

4. The structure is composed of bars which have a stress-strain relation

$$\sigma = B\varepsilon^3 \quad (\sigma,\ \varepsilon > 0)$$

All the bars have the same area A. Determine u in terms of p, B, A and H using stationary potential energy. (12%)

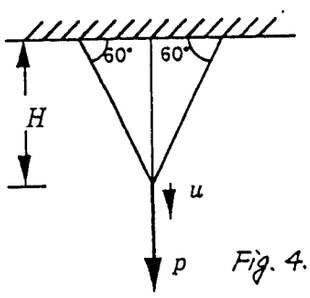

Fig. 4.

5. Two parallel cold-rolled stainless-steel (Young's Modulus E, width b, thickness t) bars will be used to support a concentrated load P at the end of a L span. The bars will be fixed to a rigid wall at the left end and there's a rigid block placed securely at a distance s from the left end as shown in the following figure. Please determine the deflection of both beams in terms of P, L, s, E, t, b and a via singularity function method. Please also determine the value of s which will make the deflection of the right end of the upper beam a minimum. (Assume that the thickness of the rigid block in the x-direction can be ignored) (15%)

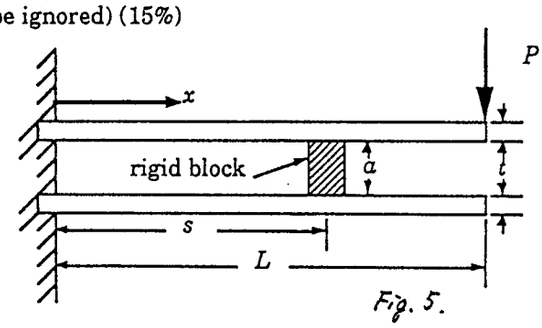

Fig. 5.

$$\sigma = B\varepsilon^3 \quad (\sigma,\ \varepsilon > 0)$$

$$\tau = G\gamma^2 \quad (\pi,\ \gamma > 0)$$

This spring consists of n turns of wire with radius r. Please find the deflection of the spring and hence the spring constant. Here, we assume the effect of the transverse shear force is very small in comparison with torsion. (15%)

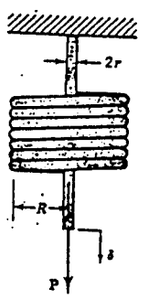

Fig. 6

7. Please explain the following terms in detail.
   (a) Creep(2%)
   (b) Neutral surface of a beam(2%)
   (c) Governing equations for Mohr's circle in a plane stress case(4%)