Massachusetts Institute of Technology
Department of Aeronautics and Astronautics
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16.001/16.002 Unified Engineering I, II
Fall 2008

Problem Set 11

Name: ________________________

Due Date: 11/21/2008

	Time Spent (min)
M21	
M22	
T23	
S8	
S9	
Study Time	

Announcements:

Unified Engineering Problem Set 11 **Lectures: M20, M21, M22**
Week 12 Fall, 2008 **Units: M3.1, M3.2 (part)**

M21 (M12.1) ***(15 points)*** A truss is to be made of a number of bars, all of the same circular cross-sectional shape and the same given length. The cross-section is a circular tube with a constant inner radius, a, for all cases, and a thickness that is constant for a given design but can change dependent upon the material used. Each bar must carry a constant load, in either tension or compression, of no greater a magnitude than P. The key design criteria at this point are that the bars are to deform as little as possible and weigh as little as possible. Cost is also a consideration. The design variables are the wall thickness of the bar and the material used to make the bar. It can be assumed that the wall thickness of the bar is significantly smaller than the radius.

(a) Determine the figure(s) of merit that is/are pertinent in this case.

(b) For the materials listed in the accompanying table, indicate which you would choose for the bar depending upon which of the three design considerations are most important: minimization of deformation, minimization of weight, minimization of cost. Be sure to clearly explain your reasoning. Use figures as appropriate.

Material	**Density** [lb/in^3]	**Modulus** [Msi]	**Strain Limit**, %	**Acquisition Cost**, [$/lb]
Silicon Carbide	0.108	60.5	2.20	162.00
Aluminum alloy (2000 series)	0.101	10.5	0.58	6.90
Wood	0.022	1.81	0.35	0.95
Steel (low carbon)	0.285	29.0	0.60	1.60
Carbon fiber Composite	0.054	24.2	0.50	88.00
Titanium alloy (TI-6Al-4V)	0.162	16.0	0.73	24.50

M22 (M12.2) ***(10 points)*** The compliance tensor is a key part of the overall set of stress-strain relationships. Let's explore these ties to the three-dimensional compliance tensor in the following way:

(a) Write out, in full, the tensorial version of the three-dimensional compliance relations for the complete anisotropic case. Group the components of the compliance tensor into the three groups (as done for the elasticity tensor in the lecture notes).

(b) Reduce these compliance relations to the orthotropic case.

Unified Engineering Fall 2008
Thermodynamics & Propulsion Z. S. Spakovszky

(Add a short summary of the concepts you are using to solve the problem)

Problem T23

An electric motor operating at steady-state draws a current of 10 A with a voltage of 220 V. The output shaft rotates at 1000 RPM with a torque of 16 Nm applied to an external load. The rate of heat transfer from the motor to its surroundings is related to the surface temperature T_b and the ambient temperature T_0 by $\dot{Q} = hA(T_b - T_0)$, where h = 100 W/m²K, A = 0.195 m², and T_0 = 293 K. Energy transfers are considered positive in the directions indicated by the arrows on the figure below. The motor is running at steady-state for 100 seconds.

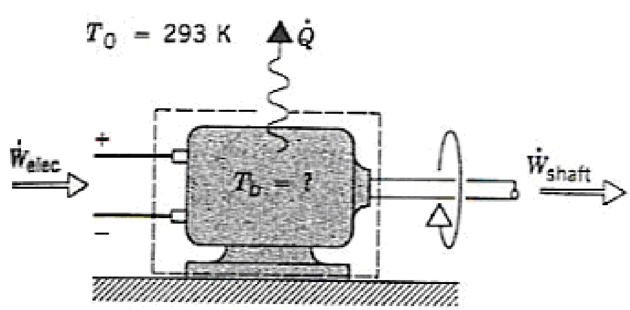
a) Determine the temperature T_b, in K.

b) What is the entropy change of the motor during steady operation?

c) What is the entropy change of the surroundings during steady operation?

d) What is the total entropy change of the surroundings plus the motor during steady operation?

e) What is the lost work during steady operation? Consider the state of the surroundings to be the reference state.



S8

a) Derive equivalent inductance formula for N inductors in series
b) Derive equivalent inductance formula for N inductors in parallel

Also: State initial condition for current in the equivalent inductor in terms of the initial current in the individual inductors

S9

a) Derive equivalent conductance formula for N conductors in series
b) Derive equivalent conductance formula for N conductors in parallel

Also: State initial condition for voltage in the equivalent capacitor in terms of the initial current in the individual capacitors