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Your Name Goes On This Line

E98 Fourth 50 Minute Exam
7 May 1997

In this examination you may use the class texts and any notes that you have taken in class or made in preparation for the exam. You may also use your homework and my homework solutions. *Make special note of the potentially useful information on the last page*. All other references are forbidden. There are three problems worth 33 points each. Your name is worth one point. The problems are of equal weight but not of equal difficulty. There is partial credit. Please write neatly and on one side of the paper only. If you use any additional paper, please attach it immediately following the sheet on which the problem statement appears.

1. Estimate the saturation magnetic moment per unit area for nickel ferrite (a = 0.834 nm) on the (110) plane.

2. A laser is being used for remote sensing. The beam exits a 5 mW HeNe laser (λ=632.8 nm), travels 250 m through Southern California air, bounces off a silver mirror, and returns toward the laser. A silica-glass collection lens sitting next to the laser focuses the beam onto a semi-conductor photodiode.
   a. What is the optical power impinging on the photodiode?
   b. What is the minimum bandgap that the photodiode can have and still function properly?

3. A sample of a composite material (63.5 vol% fibers) was experimentally tested in the longitudinal (x)-direction and in one of the transverse (y)-directions. The experimentally determined stiffness and compliance matrices are:

$$\mathbf{Q} = \begin{bmatrix} 1.419\times10^{11} & 3.232\times10^{9} & 0 \\ 3.232\times10^{9} & 8.081\times10^{9} & 0 \\ 0 & 0 & 2.706\times10^{10} \end{bmatrix}$$

and

$$\mathbf{S} = \begin{bmatrix} 7.113\times10^{-12} & -2.845\times10^{-12} & 0 \\ -2.845\times10^{-12} & 1.249\times10^{-10} & 0 \\ 0 & 0 & 3.695\times10^{-11} \end{bmatrix}.$$

The units are SI (N/m^2 or the reciprocal).

a) Estimate the elastic moduli for the fibers by themselves and the matrix by itself.
b) Calculate the changes in length and diameter for a cylindrical sample initially 1 m long and 3 cm in diameter loaded axially with a force of 49.68 kN. The fibers run axially along the cylinder

Potentially useful information

Index of Refraction for air at 6300 Å = 1.0002760

Absorption Coefficients at 633 nm

For Montana Air 1×10^{-8} cm^{-1}

For Southern California Air 5.754×10^{-6} cm^{-1}

The First Radiation Constant 0.18892×10^{8}BTU μm^4/(h ft^2)

"The time has come," the Proctor said,
"To write of many things:
Of shoes - and ships - and sealing wax -
Of cabbages - and - kings -
And why the sea is boiling hot -
And whether pigs have wings."

"But wait a bit," the Students cried,
"Before we end our test;
For some of us are out of breath,
And all of us must rest!"
"No. Hurry!" said the Professor.
They all then did their best.

Do Not Interpolate.
Use Closest Value.

Table 1: Complex Index of Refraction for Silver

λ [μm]	n	κ
0.5636	0.120	3.45
0.5904	0.121	3.66
0.6199	0.131	3.88
0.6526	0.140	4.15
0.6888	0.140	4.44
0.7293	0.148	4.74