**Physics II**
**ISI B.Math**
**Back Paper Exam : January 6, 2013**

Total Marks: 50
Time: 3 hours
Answer all questions

1. **(Marks : 3 + 4 + 3 )**

Consider the earth's atmosphere as an ideal gas of molecular weight $\mu$ in a uniform gravitational field. Let $g$ denote the acceleration due to gravity.
(a) If $z$ denotes the height above sea level, show that the change in atmospheric pressure with height is given by

$$\frac{dp}{p} = -\frac{\mu g}{RT} dz$$

where $T$ is the absolute temperature at height $z$.
(b) If the decrease in pressure in (a) is due to adiabatic expansion, show that

$$\frac{dp}{p} = \frac{\gamma}{\gamma - 1} \frac{dT}{T}$$

(c) From (a) and (b) calculate $\frac{dT}{dz}$ in degrees per kilometre. Assume the atmosphere to consist of mostly nitrogen , for which $\gamma = 1.4$.

2. **(Marks : 5 + 5 )**

(a) Calculate the maximum work in Joules obtainable from a heat reservoir consisting of 200 kg of iron heated initially to a temperature of $1500^{\circ}C$, using the ocean, at $12^{\circ}C$, as the second heat reservoir. Assume that the specific heat capacity of iron is constant and is equal to 60 joules/gram-deg.

(b) Calculate the entropy change of the universe in this process.

3. **(Marks : 5 + 5 )**

(a) Find the Helmholtz free energy for a system with only two states, one at energy 0 and one at energy $\epsilon$.

(b) From the free energy, find the expressions for the energy and the entropy of the system.

4. **(Marks : 5 + 4 + 1 )**

In double slit Fraunhofer diffraction what is the fringe spacing on a screen 50 cm away from the slits if they are illuminated with blue light ($\lambda = 4800$ $\mathring{A}$) if $d = 0.10$ mm and if the slit width $b = 0.02$ mm?

What is the linear distance from the central maximum to the first minimum of the fringe envelope?

Approximately how many fringes are contained in the central peak of the fringe envelope ?

5. **(Marks : 6 + 4 )**

(i) A disabled tanker leaks kerosene (n = 1.20) into the Persian Gulf, creating a large slick on top of the water(n =1.30). (a) If you are looking straight down from an airplane , while the sun is overhead, at a region of the slick where its thickness is 460 nm, for which wavelength(s) of visible light is the reflection brightest because of constructive interference ? (b) If you are scuba diving directly under the same region of the slick for which wavelength(s) of visible light is the transmitted intensity strongest ?

(ii) Each of four pairs of light waves arrives at a certain point on the screen. The waves have the same wavelength. At the arrival point their amplitudes and phase differences are
(a)$2E_0, 6E_0$ and $\pi$ radians (b)$3E_0, 5E_0$ and $\pi$ radians (c) $9E_0, 7E_0$ and $3\pi$ radians (d)$2E_0, 2E_0$ and 0 radians. Rank the four pairs according to the intensity of light at those points, greatest first.