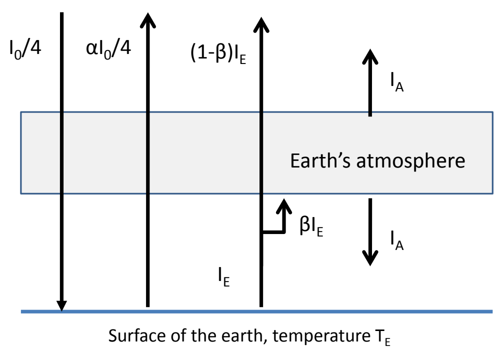
PHYS 346 - Midterm II

March 16, 2012

37 pts total

Closed book exam. Calculators are permitted. Please attempt all questions and show your work on the exam booklet provided. Please present your questions in the order in which they appear, leaving blank pages for questions not attempted. Equations and other useful information can be found at the back of the exam.

1. (8 marks) The figure below shows various energy inputs and outputs for electromagnetic radiation at the surface of the earth and the atmosphere.



   (a) For each of the radiation flows in the figure below, state its physical origin as well as the wavelength of each contribution.

   (b) What is the effect on T_E of an increase in α? An increase in β? Briefly justify your statements.

2. (6 marks) The Chevy Volt car is powered by a lithium ion battery module operating at 300V with a total capacity of 45 A·hr.

   (a) How much current does the battery supply at the peak rated power output of 111 kW?

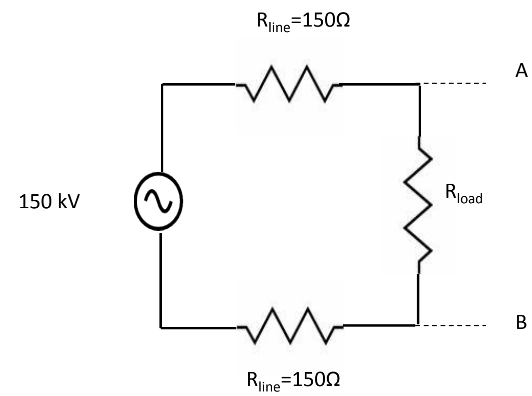
   (b) How much energy can the battery store? Express in kW·hr and MJ.

   (c) If the car requires 2.4 kW·hr to travel 10 km, how far can it travel on a single battery charge with no gasoline backup?

   (d) If the energy for recharging a battery is purchased from the power company at 8 cents/kW·hr, what is the cost of travelling 20 km?

(e) If gasoline costs \$1.30 per liter what is the cost of running the car on gas for 20 km, assuming a fuel consumption of 5 liters per 100 km?

3. (8 marks) The figure below shows a circuit diagram of a town supplied by a 150 kV AC power station. The power is delivered by two power lines with resistance $R_{line} = 150\Omega$. The voltage source is initally delivering 12MW of average power.



(a) Find the resistance R_{load}.

(b) Find the voltage delivered across R_{load}.

(c) How much power is lost to resistance in the transmission lines?

(d) It is proposed that a second town of identical load resistance R_{load} be connected in parallel to the town (across points A and B in the diagram). How much power must the generator now supply?

(e) If the transmission lines are made of copper, and have a diameter of 2 cm, what is their length?

4. (2 marks) A step up transformer boosts the voltage from 4 kV to 250 kV. If the power delivered into the transformer is 100 kW, what is the primary current (input) and the secondary current (output). (All voltages/currents are rms)

5. (3 marks) Given that the intensity of solar radiation measured at the top of the earth's atmosphere is 1368 W/m^2, estimate the surface temperature of the sun. Data for the sun and earth are given at the end of the exam.

6. (3 marks) Two large parallel metal plates have a separation of 10 cm. The upper plate is at 10V and the lower is at 0V. What is the force on a $q = -10\mu C$ charge located between the plates (magnitude and direction)?

7. (2 marks) A DC transmission line consists of two wires, supply and return as shown in the figure below. The wires are separated by 2 m. Each wire carries 100 A of peak current. What is the magnetic field exactly halfway between the wires (magnitude and direction)? Justify your answers.

8. (2 marks) Briefly explain two advantages of three phase power transmission compared with single phase (2 wire).

9. (3 marks) Calculate the energy in eV of a typical x-ray photon of wavelength 3nm. Explain why this is more likely to cause biological damage than a 3GHz microwave photon from a cell phone.

Equations and other useful information

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\begin{aligned}
KE_{trans} &= \frac{1}{2}\ m\ v^2 \\
PE_{grav} &= m\ g\ h \\
k &= \ln(1+\lambda) \\
T &= \frac{1}{k}\ln\left(\frac{kQ_T}{N_o}+1\right) \\
P\ V &= n\ R\ T \\
Q &= m\ c\ \Delta T \\
Q &= m\ L_F \\
Q &= m\ L_v \\
\eta &\leq \frac{T_H - T_C}{T_H} \\
\text{C.O.P.}_{refrig.} &\leq \frac{T_C}{T_H - T_C} \\
\text{C.O.P.}_{heatpump} &\leq \frac{T_H}{T_H - T_C} \\
c &= f\ \lambda \\
E &= hf \\
I(T) &= \sigma T^4 \\
I(T) &= I_0 e^{-kx} (Beer's Law) \\
\lambda_{max} &= \frac{B}{T} \\
B &= 2.898 \times 10^6 nmK
\end{aligned}
$$

$$
\begin{aligned}
F_E &= qE \\
\Delta W &= q\ E\ \Delta x \\
E &= -\frac{\Delta V}{\Delta x} \\
I &= \frac{\Delta q}{\Delta t} \\
R &= \frac{\rho\ L}{A} \\
\Delta U &= q\ \Delta V \\
V &= I\ R \\
P &= V\ I \\
P &= I^2\ R \\
P_{avg} &= \frac{V_p I_p}{2} \\
P_{avg} &= V_{rms} I_{rms} \\
B &= \frac{\mu_o I}{2\pi r} \\
emf &= -\frac{d\Phi}{dt} \\
\Phi &= N\ B\ A\ \cos\theta
\end{aligned}
$$

radius of the sun	6.98×10^{8} m
average earth-sun distance	1.50×10^{11} m
atomic mass of carbon	12.00 g/mol
atomic mass of oxygen	16.00 g/mol
resistivity of copper	$1.72\times10^{-8}\Omega$m
ρ_{H_2O}	1.00×10^{3} kg/m^3
specific heat for H_2O	4186 J$\cdot$kg$^{-1}\cdot$K^{-1}
latent heat of fusion H_2O	3.33×10^{5} J/kg
latent heat of vaporization H_2O	2.26×10^{6} J/kg
e	1.602×10^{-19} C
1 eV	1.602×10^{-19} J
h	$6.626\times10^{-34} J\cdot$s
ϵ_o	8.854×10^{-12} F/m
μ_o	$4\pi\times10^{-7}$ T$\cdot$m/A
g	9.8 m/s^2
σ	5.67×10^{-8} W/m^2/K^4