Physics 2

Elementary Physics of Energy

Practice Second Midterm

2 June 2012
Solution to be posted on 6th June 2012

1. Two resistors with resistances 2 Ohms and 3 Ohms are connected to a 10 V battery,
   (a) in series
   (b) in parallel.
   For each case find the voltage drop across each, the total current in the circuit and the amount of Joule heating produced in each resistor. [25]

   Solution:

   a) In series the total resistance is 2+3= 5 Ohms, and hence I, the current in the circuit is $I = V/5 = 2$ Amps. The voltage drop V_{drop} across the two resistors is given by $I \times R = 4, 6$ Amps, and the Joule heating by $P_{Joule} = V_{drop} \times I = 8, 12$ Watts.

   b) In parallel, the voltage drop across each resistor is the same $V_{drop} =$ 10 V, and hence the two currents are given by $I = V_{drop}/R = 5, 10/3$ Amps. The Joule heating is given by $P_{Joule} = V_{drop} \times I = 50, 33.3$ Watts. The total current is found by adding the two parts $I_{total} = 5 + 10/3 = 25/3$ Amps.

2. A power plant generates 1000 MW which is transmitted by a power line that carries a current of 500 Amps. If the end voltage is 800,000 V what is the resistance of the line?[25]

   Solution:

   The initial voltage can be found by using $P = V_{initial} \times I$, and since $P = 10^9$ Watts and $I = 500$ Amps, $V_{initial} = 2 \times 10^6$ Volts.

   The resistance of the line follows from using $R = (V_{initial} - V_{final})/I =$ 2400 Ohms.

3. A car wash needs 500 gallons of water a day heated from 50^0F to 100^0F. How large a solar collector would be needed to do this? The incident

insolation is 1000 Btu/ft^2 and the collector efficiency is 30%.[20]

Solution: Heat required is calculated in terms of Btu as follows:

1) 500 gallons water equal 66.85 ft^3 (using 1 gallon = .1337 ft^3). The density of water is 62.4 lb/ft^3 and so this weighs 4171 lbs.

2) Temperature difference is 50^0F and hence we need $50 \times 4171 = .2 \times 10^6$Btu.

3) If A is the area in square feet, the heat collected from the insolation times efficiency (.3) is $A \times .3 \times 1000$ Btu. Equating this to $.2 \times 10^6$Btu we find $A = 695\ ft^2$.

4. a) A hydel project has a head of 90 meters, and the river is known to deliver 1 Billion litres per hour of water. Assuming 80% efficiency, find the energy we can extract from the project per day. [15]

Solution:

The power P is given in terms of the rate of flow of the mass of water m/t) and head h as $P = (m/t)gh$. This super river has $m/t = 10^9\ kg/hr$ hence $P = 90 \times 9.8 \times 10^9$ kgs meter^2 / ($sec^2 \times hour$). Hence the energy in 24 hours at 80% efficiency is found from 24 $hrs \times P = 0.8 \times 2.1 = 1.68 \times 10^{13}$Joules.

b) How much power can be generated from a lake 1km long by 9 km wide and depth 250 meters by draining it through a water fall of height 500 meters over 1 year (1 yr = 3.15×10^7 sec)?[15]

The volume of water is 2.25×10^9 cubic meters. Since 1 cubic meter = 10^3 litres, the volume is 2.25×10^{12} litres and the weight is 2.25×10^{12} kgs. The power is therefore found as $P = m/t \times g \times h = 3.5 \times 10^8$ Watts.