Physics 6 **Spring 2005**

Some Practice Problems for Exam 2

SOLUTIONS

1. What is the probability of getting *only* 2 heads in 4 tosses of a coin?
   There are 4!/(2!2!)=6 ways to have 2 heads distributed among 4 tosses. You do not need the formula for this; just count the possibilities (HHTT, HTHT, HTTH, THHT, THTH, TTHH). The probability for 2 heads and 2 tails (in any order) is $(1/2)^2(1/2)^2$ for one of those orderings. So the overall probability is $6/(2)^4$=6/16=3/8=0.375

2. What is the probability of getting *at least* 2 heads in 4 tosses of a coin?
   Add the prob for 2 heads in 4 tosses (from above) to prob for 3 heads in 4 tosses (4!/3!=4 orderings times $(1/2)^3(1/2)^1$ or 4/16=1/4) to prob for 4 heads in 4 tosses (1/16). Get 3/8+1/4+1/16=11/16=0.6875

3. Consider **4-sided dice**.
   a. What is the probability of getting *exactly* 2 number 3's in 4 tosses?
      6 orderings (as in (1) above) times $(1/4)^2$ for two number 3's and $(3/4)^2$ for two not number 3's OR $6(1/4)^2(3/4)^2$=54/256=0.211
   b. What is the probability of getting *at least* 2 number 3's in 4 tosses?
      As in (2) above: $54/256+4(1/4)^3(3/4)+(1/4)^4$=(54+12+1)/256=67/256=0.262
   c. In two rolls of the 4-sided die, what is the probability that the second roll will have a higher number than the first?
      Arrangements that satisfy this:
      4 and (1, 2 or 3)
      3 and (1, 2)
      2 and (1) or a total of 6 arrangements.
      Each of these pairs has a probability factor of 1/4 for the first one and 1/4 for the second one to give $6(1/4)^2$=6/16=0.375

4. The sun is about 92 million miles or 150 million kilometers away from the earth. The peak wavelength of sunlight is about 5.1×10^{-7}m.
   a. How long does it take for the sun's light to get to the earth?
      Time=distance/speed=1.5×10^{11}m/(3.0×10^{8}m/s)=500 s = 8.3 min
   b. Take the peak wavelength to be the average. At the earth sunlight imparts EM power of about 700 Watt/m^2. How many photons fall on a square meter in 1 second?
      700 Joules/m^2 in 1 sec or 700 Joules of EM radiation on 1 m^2 every second. One photon with $\lambda=5.1\times10^{-7}$m has
      $f=c/\lambda=(3.0\times10^{8}\text{m/s})/(5.1\times10^{-7}\text{m})=5.88\times10^{14}\text{s}^{-1}$ and energy
      $hf=(6.6\times10^{-34}\text{J}\cdot\text{s})(5.88\times10^{14}\text{s}^{-1})=3.9\times10^{-19}$J. So we have
      700 J/(3.9×10^{-19}J per photon)=1.8×10^{21} photons

5. Electrical wires connected to a wall plug (in the US) emit EM radiation of frequency 60 Hertz.
   a. What is the wavelength of that radiation? Is it visible?

λ=c/f=(3.0x10^8m/s)/(60 s^{-1})=5.0x10^6m   Not visible

b. What is the energy of one photon emitted?

hf=(6.6x10^{-34}J·s)(60 s^{-1})=4.0x10^{-32}J

6. A proton travels at (1/300)c. What is its deBroglie wavelength? Mass of the proton is 1.67x10^{-27}Kg.

V=c/300=1.0x10^6m/s

λ_{deB} =h/p=h/mv=

(6.6x10^{-34}J·s)/([1.67x10^{-27}Kg]1.0x10^6m/s)=4.0x10^{-13}m

7. A hydrogen atom undergoes a transition from the n=5 to the n=2 state. What is the wavelength of the photon emitted? Is it visible?

Energy difference

-13.6/$(5)^2$ -(-13.6/$(2)^2$) eV =13.6eV(1/4 - 1/25) =2.856eV or

2.856eV·1.60x10^{-19}J/eV=4.570x10^{-19}J

One photon emission has energy

hf=4.570x10^{-19}J

Then frequency f=(4.570x10^{-19}J)/h= (4.570x10^{-19}J)/(6.6x10^{-34}J·s)

=6.92x$10^{14}$$s^{-1}$

So wavelength

λ=c/f=(3.0x10^8m/s)/(6.92x$10^{14}$$s^{-1}$)=4.3x$10^{-7}$m   Visible

8. An electron is confined to a microscopic tube of length 10^{-8} m. What is the best precision, i.e. the smallest *uncertainty* with which its momentum and velocity can be measured? Mass of electron is
9.11x10^{-31}Kg.

It is confined to 10^{-8} m so its position is known within an uncertainty of

Δx = 10^{-8} m

Then the uncertainty in momentum will be $\Delta p \geq h/(2\cdot 2\pi\cdot \Delta x)$. The smallest Δp will be the equality,

Δp = h/(2·2π· Δx)= (6.6x10^{-34}J·s)/(4π·10^{-8}m)=5.25x10^{-27}J·s/m

Δp=mΔv so Δv=(5.25x10^{-27}J·s/m)/(9.11x10^{-31}Kg)=5770 m/s

9. One day 2 inches of rain fell in the Boston area. How many gallons of water fell on the Tufts campus? (This is an estimation problem.)