PHYS 2D
PROBLEM SESSION

2012/5/10

4.7

- Millikan's oil drop experiment
- Given a, ρ, time/distance of fall $\Delta t_f/\Delta y_f$, time/distance of rise $\Delta t_r/\Delta y_r$, separation/potential difference of plates $\Delta x/\Delta V$
- Want to find q on oil drop
- $q=(mg/E)[(v+v')/v]$
  - m: $4\pi a^3\rho/3$
  - $E=\Delta V/\Delta x$
  - $v= \Delta y_f/\Delta t_f$
  - $v'= \Delta y_r/\Delta t_r$

4.25

- Frequency of photon from n=4 to 3 of hydrogen
  - $E_\gamma = hf = -13.6eV(1/4^2 - 1/3^2)$
  - $h = 4.136*10^{-15}$ eV*s
  - $f = 1.60*10^{14}$ Hz
- Frequency of revolution of e^- in these orbits
  - $f = 1/T = v/2\pi r$
  - $K = mv^2/2 = 13.6/n^2$ eV, $L = mvr = n\hbar$
  - $f = K/\pi L = 27.2eV/n^3h = 6.58*10^{15}/n^3$ Hz
  - $f_3 = 2.44*10^{14}$ Hz
  - $f_4 = 1.03*10^{14}$ Hz

5.10

- Compare kinetic energy of electron with $\lambda=2a_0$ to hydrogen ground state energy
  - $\lambda=2a_0=h/p=h/mv$
  - $K=mv^2/2=(h/2a_0)^2/2m=2.15*10^{-17}$ J=135eV
  - $v<<c$
  - Hydrogen $E_{n=1}=-13.6$eV

5.18

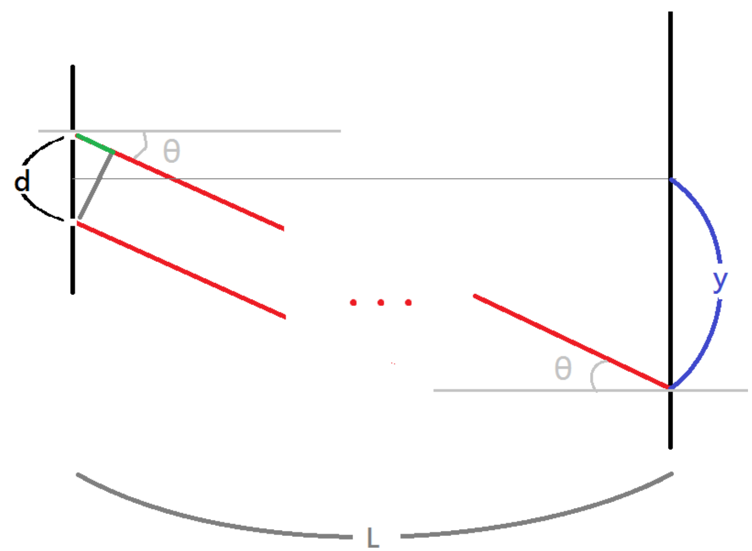
- Ball with $m=50g$, $v=30m/s$. Accuracy of $v=0.1\%$, find minimum Δx
  - $v<<c$
  - $\Delta p=m\Delta v=0.05*30*0.001=1.5*10^{-3}$ J*s/m
  - $\Delta p\Delta x\geq\hbar/2$
  - $\Delta x\geq1.055*10^{-34}/(2*1.5*10^{-3})=3.5^{-32}$ m

5.23

- If $\hbar=1$ J*s, $m=2$ kg, $\Delta x=1$ m, $\Delta p=?$
  - $\Delta p \Delta x \geq \hbar/2$
  - $\Delta v \geq 1/4$ m/s
- If $\Delta v \geq 1/4$ m/s for $t=5$ s, find Δx afterwards
  - $x=[x_0, x_0+1]$
  - $v=[v_0, v_0+\Delta v]$
  - $x'=vt+x=[v_0 t+x_0, (v_0+\Delta v)t+x_0+1]$
  - $\Delta x'=5^* \Delta v+1=2.25$ m

5.28

- Neutron beam with v=0.4 m/s pass through double slit with separation d=10^{-3} m, detector at L=10 m away. Find λ of neutron, y of 1st zero
  - $\lambda = h/mv = 9.92 * 10^{-7}$ m
  - Destructive interference: $d\sin\theta = (n+1/2)\lambda$, $\sin\theta \approx y/L$
  - n=0, $y = L\lambda/2d = 4.96 * 10^{-4}$ m
  - Can not say which one slit neutron passed through, it's not behaving like a particle

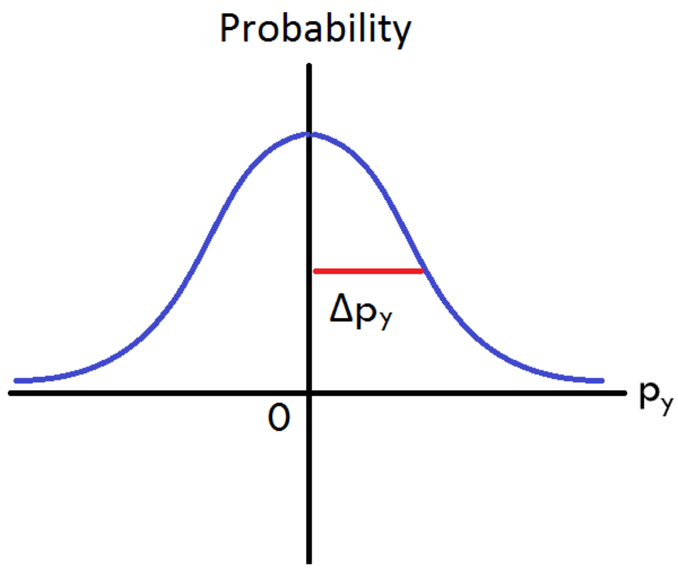


5.31

- 1 g particles with v_x=100 m/s are shot through hole of diameter 2 mm, how far from the hole must you be to see the beam spread by 1cm
- At the hole, what we know is the uncertainty in y, $\Delta y=2*10^{-3}$ m
- $\Delta p_y \geq \hbar/2\Delta y \approx \hbar/\Delta y$, $v_y=0+\Delta p_y/m \approx 5.2*10^{-29}$ m/s
- For the particle to move 0.5 cm in the y direction, it takes $t \sim 0.005/\Delta v_y = 9.5*10^{25}$ s
- In this time particle moved $t*v_x=1.9*10^{27}$ m

5.31

- $\Delta p_y \Delta y \approx \hbar$



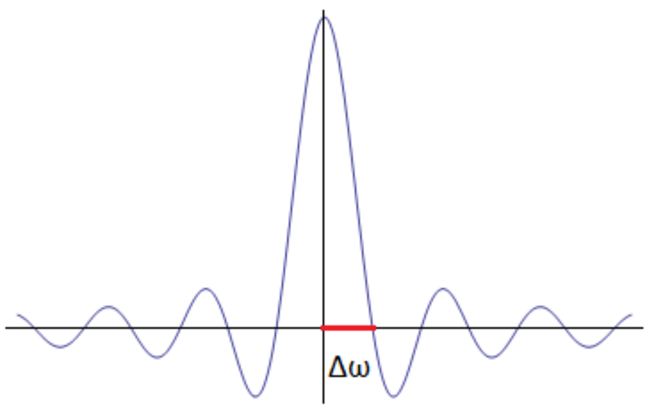
- Measurement of p_y will most likely give a result between ~-2 or -3Δp_y to+2~+3Δp_y
- Rough estimate

5.34

- Given a rectangular wave pulse, find its spectral content
- The inverse of example 5.7, where the spectral content is a rectangular pulse

$$g(\omega) = (2\pi)^{-1/2} \int_{-\infty}^{\infty} V(t)(\cos\omega t - i\sin\omega t)\,dt = 2(2\pi)^{-1/2} \int_{0}^{\tau} V_0 \cos\omega t\,dt = \left(\frac{2}{\pi}\right)^{1/2} V_0 \frac{\sin\omega\tau}{\omega}$$

- First zero at ω=π/τ
- Take that as Δω
- τΔω=ΔtΔω=π
- τ=0.5μs, 2Δω=2π/τ=1.26*10^7 Hz
- τ=0.5ns, 2Δω=1.26*10^{10} Hz



- Questions?