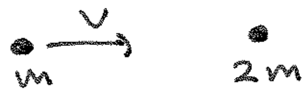
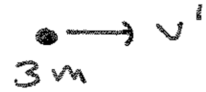
Midterm 2

Problem 1

(a) initial:



final:



Conservation of momentum:

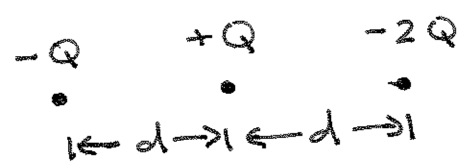
$p_i = p_f \qquad m \cdot v = (3m) \cdot v' \quad \Rightarrow \quad \boxed{v' = \frac{1}{3} v}$

(b) $K_i = \frac{1}{2} m v^2$

$K_f = \frac{1}{2}(3m)\left(\frac{1}{3}v\right)^2 = \frac{1}{3} K_i$

$\Rightarrow \frac{2}{3}$ of initial kinetic energy converted to heat etc.

Problem 2

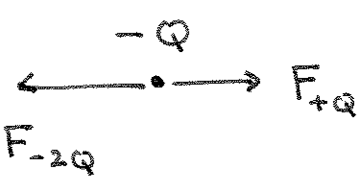


Force due to +Q: $F_{+Q} = k\frac{Q^2}{d^2}$

dir = right (attractive force)

Force due to -2Q: $F_{-2Q} = k\frac{Q \cdot 2Q}{(2d)^2} = \frac{1}{2} k \frac{Q^2}{d^2}$

dir = left (repulsive)

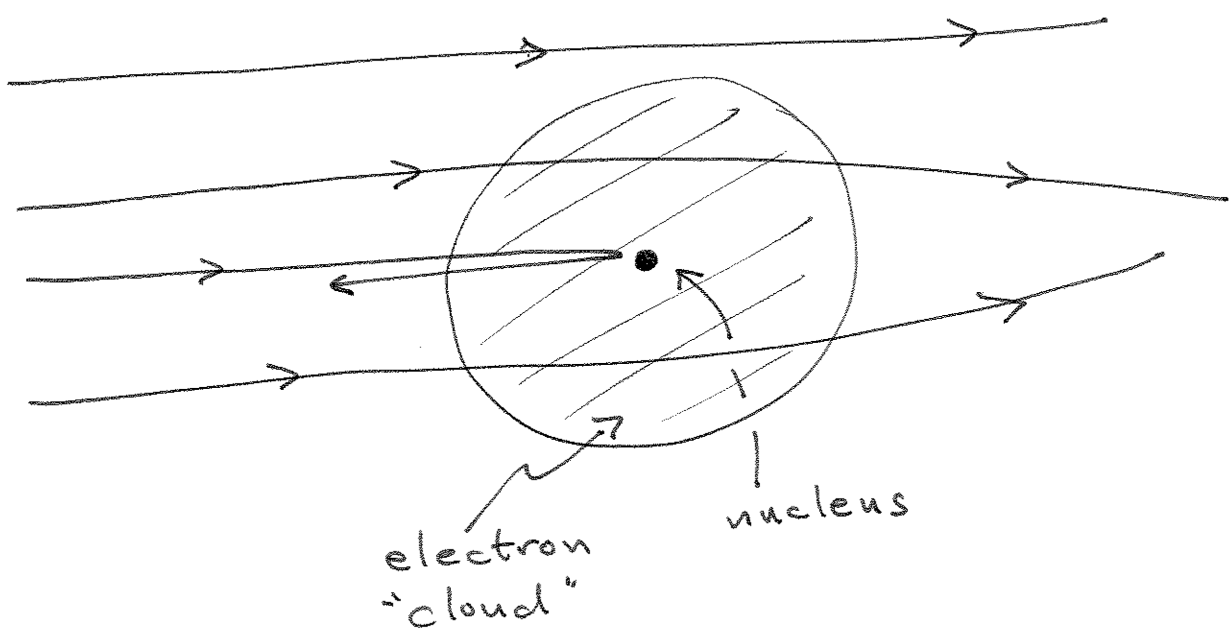


$$\text{Total force} = k\frac{Q^2}{d^2} - \frac{1}{2}k\frac{Q^2}{d^2} = \frac{1}{2}k\frac{Q^2}{d^2}$$

F_{+Q} is larger $\Rightarrow$ net force is toward right

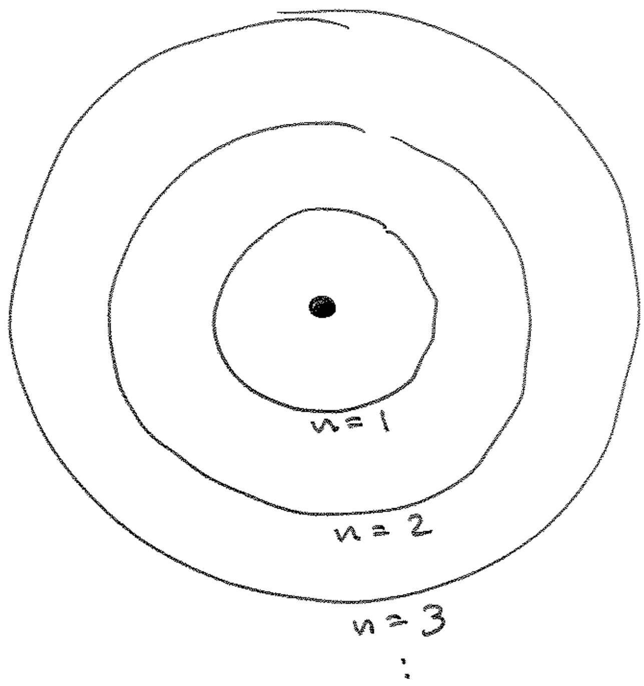
Problem 3

Rutherford directed a beam of electrons at a metal foil. Most electrons passed through the foil with only a small deflection in their direction. The surprise was that a small fraction of the electrons were deflected nearly straight back. This was interpreted as the result of rare collisions between the incident electrons and a small massive nucleus.



Problem 4

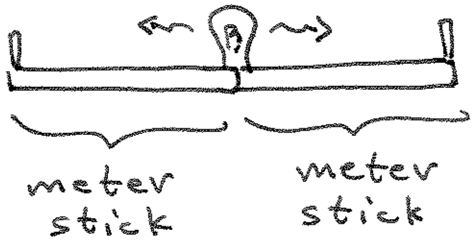
According to Bohr's model, the allowed orbits of the electron around the nucleus are discrete and are labelled by an integer n.



The innermost orbit (n=1) has lowest energy and is therefore stable. The spectral lines are due to electrons going from one allowed orbit to another. The frequency of the light emitted is related to the energy difference between the initial and final orbits.

Problem 5

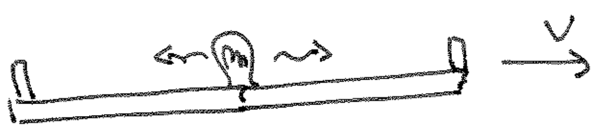
Consider the device (discussed in class):



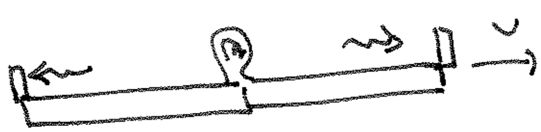
bulb flashes

light hits both ends of meter sticks simultaneously

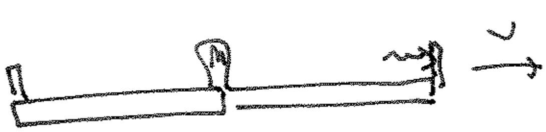
Now set it in motion (or equivalently, observe from moving frame)



bulb flashes



light hits left end ***first***



light hits right end

Even though bulb is moving, light in both directions travels with same speed c!