f **Fermilab**

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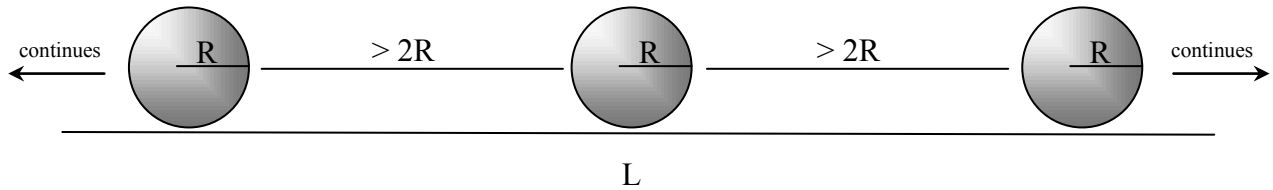
Rolling with Rutherford



Ernest Rutherford may be best known for determining that the nucleus was a tiny volume containing positive charge. He probed the nucleus by aiming alpha particles at metal foil and looking at the patterns made by the recoiling alpha particles. He found that most of them passed right through the foil. Students can simulate Rutherford's work with ball bearings and a meter stick. The end result will be an indirect calculation of the radius of one of the balls in the array above.

We first need to work out the probability of the rolling ball striking one of the target balls. The two will hit when their centers are closer than the sum of their radii. The probability of this happening is the ratio of the summed radii to the total width of the target area. If more than one target ball is present, then the probability increases by a factor of the number of balls present. In symbols this is:

$$P = N\frac{2(R+r)}{L}$$

We can also measure the probability by rolling the ball at the target area and counting the number of hits:

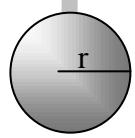
$$P = \frac{H}{T}$$

These two terms for P can be set equal and solved for the target radius R:

$$R = \frac{HL}{2TN} - r$$

H is the number of hits.
L is the length of the target region.
T is the number of trials.
N is the number of target balls.
r is the radius of the probe.

One can write this much more simply if the target and the probe are the same size.



Probe – Roll towards the screened target a large number of times. Keep track of the hits and total number of trials.