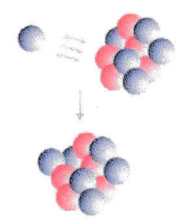
Consolidation: Kinematics & Dynamics

Formula Summary	
Kinematics	**Dynamics**
1. $\Delta d = \frac{V_1+V_2}{2}\Delta t$	Newton's Second Law
2. $a = \frac{V_2 - V_1}{\Delta t}$	$F_{net} = ma$
3. $\Delta d = V_1\Delta t + \frac{1}{2}a\Delta t^2$	Force of Gravity
4. $\Delta d = V_2\Delta t - \frac{1}{2}a\Delta t^2$	$F_g = mg$ $g = 9.8\,m/s^2$ (earth)
5. $V_2^{\,2} = V_1^{\,2} + 2a\Delta d$	Friction
	$F_f = \mu F_n$

1. Stopping a Neutron: When a nucleus captures a stray neutron, it must bring the neutron to a stop within the diameter of the nucleus by means of the *strong force.* That force, which "glues" the nucleus together, is approximately zero outside the nucleus. Suppose that a stray neutron with an initial speed of 1.4×10^{7} m/s is just barely captured by a nucleus with diameter $d = 1.0 \times 10^{-14}$ m (the stopping distance). Assuming that the strong force on the neutron is constant, find the magnitude of that force. The neutron's mass is 1.67×10^{-27} kg.



2. Pushing a sled on rough snow: A girl is pushing a 55 kg sled horizontally on rough snow that has a coefficient of kinetic friction equal to 0.50. She pushes with a force of 380N for a distance of 15m (assume the sled starts from rest). After this 15m the girl stops pushing and allows the sled to come to a sliding rest on the snow.

a. How far does the sled travel before stopping?
b. How long does it take for the sled to come to a rest?

3. Take Off: A Navy jet with a mass of 2.3×10^{4} kg requires an airspeed of 85 m/s for liftoff. The engine develops a maximum force of 1.07×10^{5} N, but that is insufficient for reaching takeoff speed in the 90 m runway available on an aircraft carrier. What minimum force (assumed constant) is needed from the catapult that is used to help launch the jet? Assume that the catapult and the jet's engine each exert a constant force over the 90 m distance used for takeoff.

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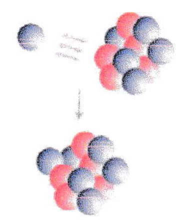
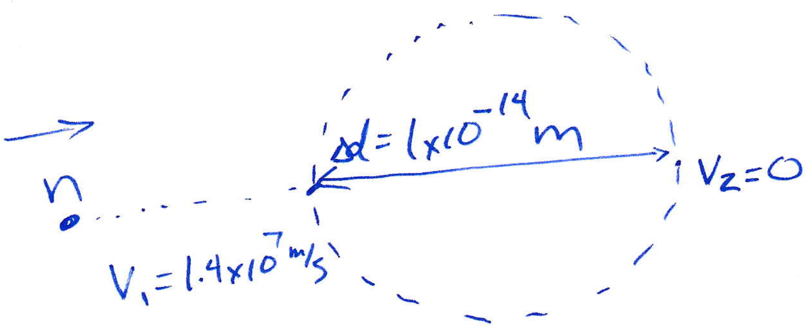
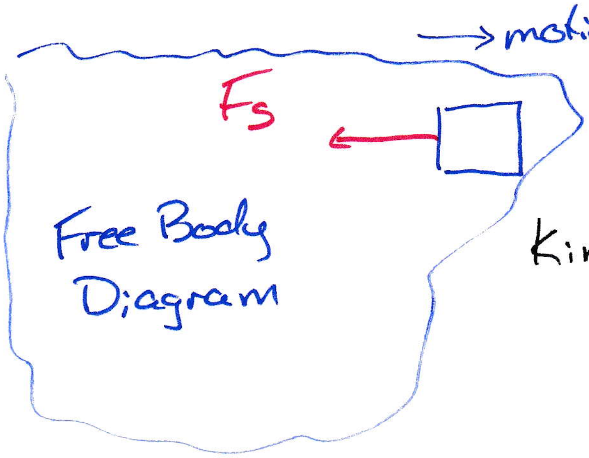


$m = 1.67 \times 10^{-27}$ kg.



Unknown = $F_{strong\ nuclear}$



$F_{net} = ma = F_s$

Kinematics: V_1, V_2, Δd

a

(5) $a = \dfrac{V_2^2 - V_1^2}{2\Delta d}$

$a = -9.8 \times 10^{27}$ m/s²

$F_s = ma$

$= 16.4$ N [←]

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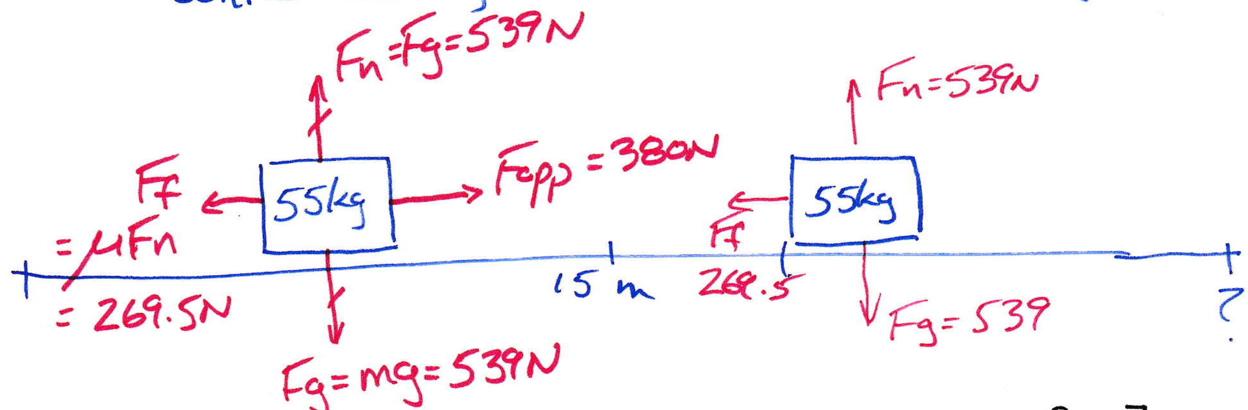
While Pushing

After let go.



While pushing:

$F_{net} = 380N - 269.5 = 110.5N [\rightarrow]$

$a = F_{net}/m = \frac{110.5N}{55kg} = 2.01 m/s^2 [\rightarrow]$

$V_1 = 0$

$\Delta d = 15m$

$a = 2.01 m/s^2$

⑤ $V_2 = 7.764 m/s$

After let go:

$F_{net} = 269.5 [\leftarrow]$

$a = -4.9 m/s^2$
$(4.9 m/s^2 [\leftarrow])$

$V_1 = 7.764 m/s$

$V_2 = 0$

$a = -4.9 m/s^2$

⑤ $\Delta d = \frac{V_2^2 - V_1^2}{2a} = 6.15m$ *

② $\Delta t = \frac{V_2 - V_1}{a} = 1.58s$ *

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m

$V_1 = 0$ ← $\Delta 90\text{m}$ → $V_2 = 85 \text{ m/s}$

(5) $a = \dfrac{V_2^2 - V_1^2}{2\Delta d} = 40.14 \text{ m/s}^2$ (~4 g's)

$F_{net} = ma = 923194\text{N}$

F_n

$F_{catapult} = ?$

$F_{eng} = 107000\text{N}$ $(1.07 \times 10^5 \text{N})$

F_g

$F_{net} = F_{engine} + F_{catapult}$

$923194\text{N} = 107000\text{N} + F_{catapult}$

$\boxed{F_{catapult} = 820000\text{N}}$