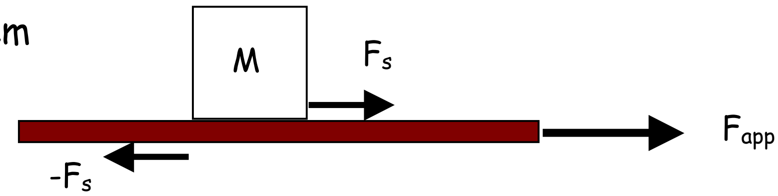
The Milk Carton Problem



1st Law - Inertia
2nd Law - F = ma

The force that pulls the milk carton along with the paper is the static friction force between the paper and the milk carton.

$$F_s^{(max)} = \mu_s * N = \mu_s * M * g$$

If the milk carton is to move with the paper then they will both have the same velocity and experience the same acceleration.

There is a direct connection between the paper and the applied force F_{app}. We can increase the value of this force to achieve any acceleration "a" of the paper that is desired.

As for the milk carton, its connection to the applied force is through the friction that exists between the paper and the milk carton. For the milk carton to experience the same acceleration as the paper it need a force F_c.

$$F_c = M * a$$

This is where the inertia (mass) comes in. It is in the application of the 2nd law and not the 1st. F_c needs to be less than or equal to the available static friction. This puts a limitation on the maximum value of "a".

$$F_c = M * a \leq \mu_s * M * g,$$

which, for $\mu_s = 0.7$, implies $a \leq \mu_s * g = 0.7g$.

If the required force exceeds the maximum static friction then the milk carton will slip and not be able to keep up with the accelerating paper. Depending on how quickly the paper is accelerated the milk carton might keep up for a very short time interval, resulting in a small velocity. However, if the static friction limit is exceeded then milk carton will not be able to successfully follow the paper. After exceeding the static friction limit there is a smaller dynamic friction that can cause the milk carton to move, but slowly. However, after the paper is no longer under the milk carton then even this small force is gone.