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Chapter 13 - Kinetics of a Particle: Force and Acceleration

Section 13.1, 13.2, 13.4

- Newton's Laws of Motion
- The Equation of Motion
- Equations of Motion: Rectangular Coordinates

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Overview: We now have some practice calculating acceleration. We'll now use $F = ma$ to calculate a given F, or vice-versa.

Newton's Laws of Motion:

First Law: A particle originally at rest, or moving in a straight line with constant velocity, will remain in that state until acted on by

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on external force.

<u>Second Law</u>: A ptcle subjected to an unbalanced external force $\vec{F}$ experiences an acceleration $\vec{a}$ that is in the same direction as $\vec{F}$, and is directly proportional to $|\vec{F}|$ ($\vec{F} = m\vec{a}$).

<u>Third Law</u>: The mutual forces of action and reaction between two ptcles are equal, opposite

University of Idaho & curvilinear. (Rigid bodies and systems of particles)

Newton's Second Law & Mass

$$\vec{F} = m\vec{a} \qquad m = \frac{|\vec{F}|}{|\vec{a}|}$$

$\uparrow$ vector resultant of applied external forces

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Assume we choose rectangular coordinates to represent our force and accel vectors.

Then

$$\vec{F} = F_x\vec{i} + F_y\vec{j} + F_z\vec{k}$$

$$\vec{a} = a_x\vec{i} + a_y\vec{j} + a_z\vec{k}$$

$$F_x\vec{i} + F_y\vec{j} + F_z\vec{k} = m(a_x\vec{i} + a_y\vec{j} + a_z\vec{k})$$

↳ Three separate scaler equations ⇒

$$F_x = ma_x$$
$$F_y = ma_y$$
$$F_z = ma_z$$

} Newton's 2nd Law in Rectangular Coords.

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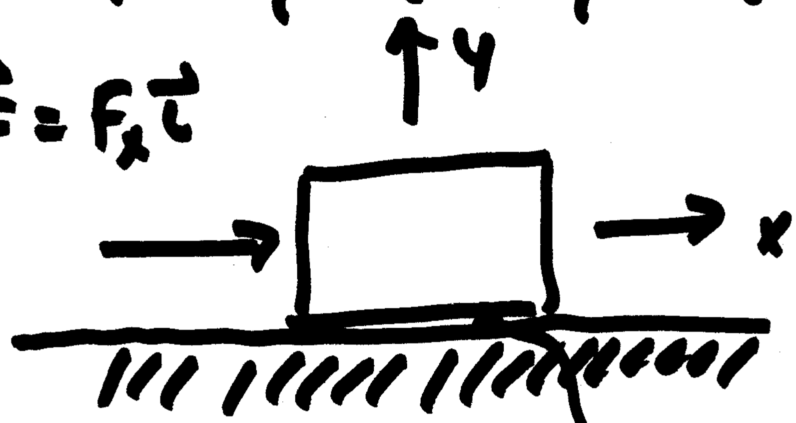
Consider 1-D motion in the x-dir; $F_y = F_z = a_y = a_z = 0$

$\vec{F} = F_x \vec{i}$



frictionless surface.

We know that $F_x = m a_x$

Metric Units; $a_x = 1\ m/s^2$; $m = 1\ kg$; $F_x = 1$ Newton

English Units $a_x = 1\ ft/s^2$; $m = 1$ slug ; $F_x = 1\ lb_f$

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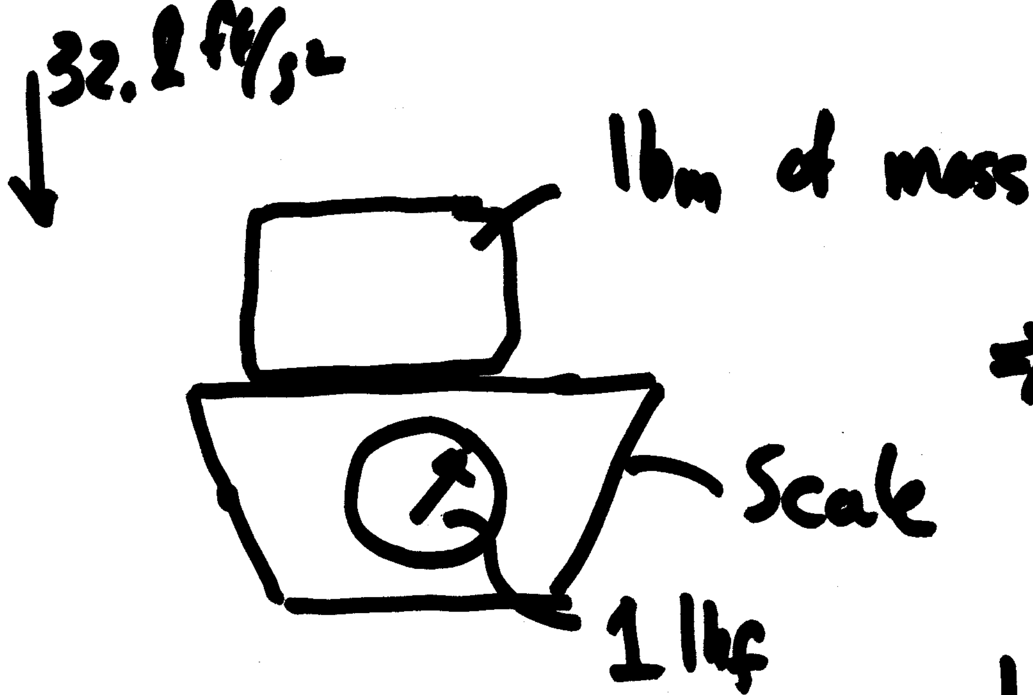
Mass in English Units are Most Commonly Given in Units of "lbm" ....

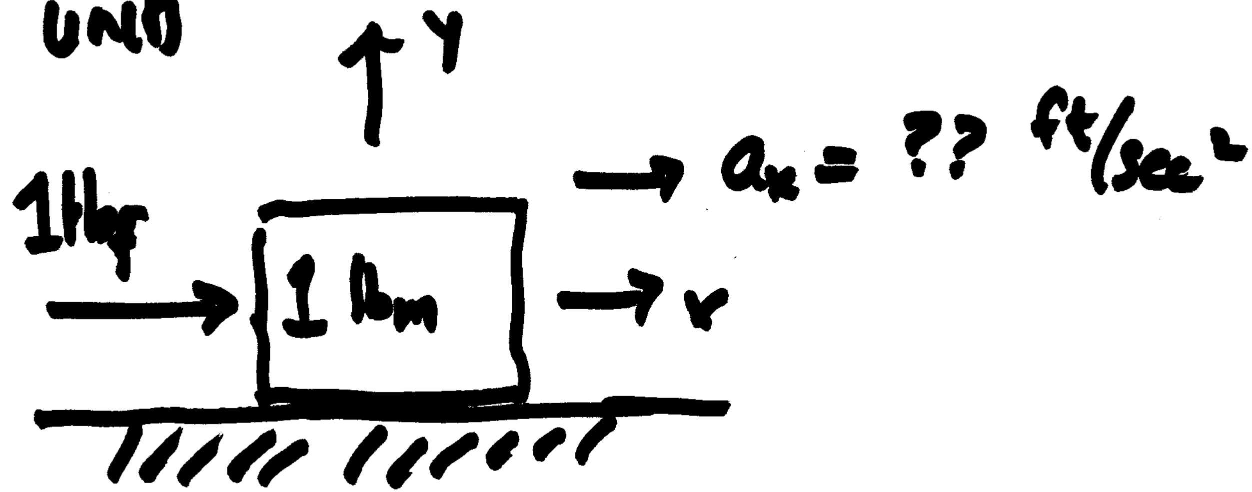


$\Rightarrow F = ma$

$1\,lb_f = 1\,lb_m \cdot 32.2\ ft/s^2$

$$1\,lb_m = \frac{lbf}{32.2\ ft/sec^2}$$

University of Idaho Lets work on example problem in English units



$$1\ lbf = 1\ lbm \cdot a_x\ ft/s^2$$

$$1\ lbf = 1\ \frac{lbf}{32.2\ ft/s^2}\left[a_x\ ft/s^2\right] \qquad a_x = 32.2\ ft/s^2$$