PhyzExamples: Newton's Laws

Physical Quantities • Symbols • Units • Brief Definitions

Acceleration • a • m/s^2 • The rate at which a body's velocity changes; a body undergoes acceleration if its speed and/or direction of travel changes. Values of acceleration must sometimes be found using kinematics equations. Sometimes expressed as a vector **a**.

> **Gravitational Acceleration** • g • m/s^2 • The vertical acceleration undergone by an object in free fall. On Earth, that acceleration is 9.8m/s^2; on the moon, it's 1.6m/s^2.

Mass • m • kg • The quantity of matter in a body; the measure of a body's resistance to acceleration. Quantity of inertia. NOT the same thing as *weight* (which is *gravitational force*).

Force • F • N or kg·m/s^2 • A measure of the push or pull involved when two bodies interact. Sometimes expressed as a vector **F**.

> **Weight** • W • N or kg·m/s^2 • The **gravitational force** between two bodies, typically an object on or near the surface of a planet and the planet itself. Most often, that planet is Earth. NOT equivalent to mass (which is a body's quantity of matter or inertia). Weight *is* gravitational force.

Equations

$F = ma$ • Newton's Second Law (**F** = m**a** in vector form)
$W = mg$ • "The Weight Equation" • Notice that it's just Newton's Second Law written with gravitational force and gravitational acceleration.

Smooth Operations Examples

1. Given m=5kg and a=7m/s^2
Find F.

1. m=5kg a=7m/s^2 F=?
F = ma
F = 5kg · 7m/s^2
F = 35N

2. Given m=12kg and F=3N
Find a.

2. m=12kg F=3N a=?
F=ma
a = F/m
a = 3N/12kg
a = 0.25m/s^2

3. Given m=6kg and **a**=(–5m/s^2, –9m/s^2)
Find **F**.

3. m=6kg a=(–5m/s^2, –9m/s^2) F=?
F=ma
F=6kg(–5m/s^2, –9m/s^2)
F = (–30N, –54N)

4. Given m=3kg and **F**=(15N; 75°)
Find **a**.

4. m=3kg F=(15N; 75°) a=?
F=ma
a=F/m
a = (15N; 75°)/3kg
a = (5m/s^2; 75°)

5. A bullet undergoes a 1000m/s^2 acceleration when acted on by a 20N force. What is the mass of the bullet?

5. a=1000m/s^2 F=20N m=?
F = ma
m = F/a
m = 20N/1000m/s^2
m = 0.02kg = 20g

6. Given x=18m, v_0=0, t=3s and m=8kg. Find a and F.

6. Solve for a using kinematics, solve for F using Newton's Second Law.

x=18m v_0=0 v=? a=? t=3s

$x = v_0t + {}^1/_2at^2$

since v_0=0,

$x = {}^1/_2at^2$

$a = 2x/t^2$

$a = 2 \cdot 18m/(3s)^2$

$\underline{a = 4m/s^2}$

$a = 4m/s^2$ m = 8kg

F = ma

$F = 8kg \cdot 4m/s^2$

$\underline{F = 32N}$

7. Given m=75kg and g=9.8m/s^2
Find W.

5. m=75kg g=9.8m/s^2 W=?

W = mg

$W = 75kg \cdot 9.8m/s^2$

$\underline{W = 735N}$

8. Given W=152N and g=3.8m/s^2
Find m.

6. W=152kg g=3.8m/s^2 m=?

W=mg

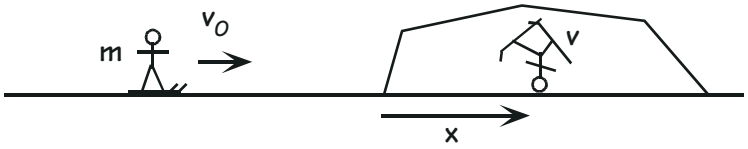
m = W/g

$m = 152N/3.8m/s^2$

$\underline{m = 40kg}$

Welcome to the Real World Examples

9. While skiing at 14m/s, 62kg Jenessa accidentally ran into a snowbank. She plowed 2.3m horizontally into the bank while coming to rest. How much force did the snow exert on her as she stopped?



9. v_0=14m/s m=62kg x=2.3m v=0 F=?

F = ma

a: $v^2 = v_0^2 + 2ax$

$a = -v_0^2/2x$

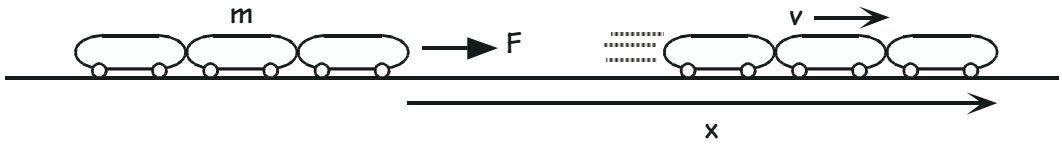
$F = m(-v_0^2/2x)$

$F = 62kg(-[14m/s]^2 / 2 \cdot 2.3m)$

$\underline{F = -2600N}$

The negative sign can be dropped; it indicates that the direction of force was opposite to the direction of Jenessa's initial velocity.

10. At the beginning of a "Tidal Wave"-style ride, a roller coaster train of mass m is accelerated in time interval t by a propelling force F. Through what distance did the train travel while accelerating?



10. m=m v_0=0 t=t F=F x=? (v=? a=?)

a=F/m

$x = v_0t + {}^1/_2at^2$

$x = {}^1/_2at^2$

$\underline{x = Ft^2 / 2m}$