

Physics 199BB
The Physics of Baseball
Summary of Useful Formulas
Updated Aug. 22, 2007

1. Definitions

Average velocity is rate of change of position $v = \Delta x / \Delta t$

Average acceleration is rate of change of velocity $a = \Delta v / \Delta t$

Acceleration due to gravity $g = 9.81 \text{ m/s}^2 = 32.2 \text{ ft/s}^2$ (downward)

2. Motion with constant acceleration

$$v = v_0 + at \quad x = x_0 + v_0t + \frac{1}{2}at^2 \quad v^2 = v_0^2 + 2a(x-x_0)$$

3. Projectile motion

$$x = x_0 + v_{0x}t \quad v_x = v_{x0}$$
$$y = y_0 + v_{0y}t - \frac{1}{2}gt^2 \quad v_y = v_{y0} - gt \quad v_y^2 = v_{y0}^2 - 2g(y-y_0)$$

4. Newton's Laws

I. An object continues in a state of rest or motion at constant velocity unless acted upon by an external force.

II. When a net force F acts on an object, it results in an acceleration given by $a=F/m$, where m is the mass (**$F=ma$**)

III. Whenever one body exerts a force on a second body, the second body exerts an oppositely directed force of equal magnitude on the first body.

5. Units

$$1 \text{ mph} = 0.447 \text{ m/s}$$

$$1 \text{ inch} = 2.54 \text{ cm}$$

$$1 \text{ lb-force} = 4.45 \text{ N}$$

$$1 \text{ lb-mass} = 16 \text{ oz} = 0.454 \text{ kg}$$

6. Useful numbers

Mass of baseball = 5.1 oz = 0.145 kg

Weight of baseball = $Mg = 0.320 \text{ lb} = 1.42 \text{ N}$

Radius of baseball = 1.43 in = 36.4 mm = 3.64 cm = 0.0364 m

Cross sectional area of baseball (πR^2) = $4.16 \times 10^{-3} \text{ m}^2$

Length of typical bat = 33 in = 0.838 m

Mass of typical bat = 32 oz = 0.908 kg

Density of air at normal temperature and pressure $\rho = 1.21 \text{ kg/m}^3$