Newton's Laws – 1

1. A 450 kg mass is accelerated at 2.5 m/s^2. (a) What is the force causing this acceleration? (b) how fast is the mass traveling at the end of 3.0 s?

(a) $F = ma \quad = 450\ kg\left(2.5\ \frac{m}{s^2}\right) \quad = \boxed{1100\ N}$

(b) $v = v_o + at \quad = 2.5\ \frac{m}{s^{\cancel{2}}}\left(3.0\ \cancel{s}\right) \quad = \boxed{7.5\ \frac{m}{s}}$

2. How much does a 34.5 kg gymnast weigh?

$w = mg \quad = 34.5\ kg\left(9.8\ \frac{m}{s^2}\right) \quad = \boxed{338\ N}$

3. A 2500 kg car is pushed with a 250 N force, (a) what is the acceleration acting on the car? (b) what is the acceleration if the mass is doubled?

(a) $F = ma \quad a = \frac{F}{m} \quad = 250\ \frac{\cancel{kg}\cdot m}{s^2}\left(\frac{1}{2500\ \cancel{kg}}\right) \quad = \boxed{0.10\ N}$

(b) $a = \frac{0.10}{2}\ \frac{m}{s^2} \quad = \boxed{0.050\ \frac{m}{s^2}}$

4. An artillery shell has a mass of 75 kg. The projectile is fired from the weapon and has a velocity of 670 m/s when it leaves the barrel. The gun barrel is 2.7 m long. (a) Assuming the force and therefore the acceleration is constant while the projectile is in the barrel, what is the force that acted on the projectile? (b) If the elevation angle is 52°, what is the horizontal range of the projectile?

$v^2 = v_o^{\,2} + 2ax \qquad a = \frac{v^2}{2x} \qquad a = \left(670\ \frac{m}{s}\right)^2 \frac{1}{2\left(2.7\ \cancel{m}\right)} \quad = \quad 83\,130\ \frac{m}{s^2}$

$F = ma \qquad F = 75\ kg\left(83\,130\ \frac{m}{s^2}\right) \quad = \boxed{6.2\ x\ 10^6\ N}$

5. The space shuttle has a mass of 2.0 x 10^6 kg. At lift off the engines generate an upward thrust of 1.3 x 10^8 N. (a) Draw a FBD of the space shuttle system.

$w = mg \quad = 2.0\ x\ 10^6\ kg\left(9.80\ \frac{m}{s^2}\right) \quad = \boxed{2.0\ x\ 10^7\ N}$

(b) What is the weight of the shuttle?

(c) What is the acceleration of the shuttle when it is launched?

$\sum F_{Net} = F_{Thrust} - w \quad = 1.3\ x\ 10^8\ N - 0.20\ x\ 10^8\ N \quad = \quad 1.1\ x\ 10^8\ N$

$F = ma \qquad a = \frac{F}{m} \qquad a = 1.1\ x\ 10^8\ \frac{\cancel{kg}\cdot m}{s^2}\left(\frac{1}{2.0\ x\ 10^6\ \cancel{kg}}\right) \quad = 0.55\ x\ 10^2\ \frac{m}{s^2} \quad = \quad \boxed{55\ \frac{m}{s^2}}$

(d) The average acceleration of the shuttle during its 7.5 minute run is 18 m/s^2. What velocity does it theoretically achieve at the end of that time?

$a = \frac{v}{t} \qquad v = at \qquad v = 18\ \frac{m}{s^2}\left(7.5\ \cancel{\text{min}}\right)\left(\frac{60\ s}{1\ \cancel{\text{min}}}\right) \quad = \quad \boxed{8\,100\ \frac{m}{s}}$

6. A 345 g hockey puck rests on a flat, smooth table. A horizontal net force of 125 N acts on it for 2.00 seconds. The puck slides across the table at the end of that time and then falls off the table. The table's top surface is 85.0 cm above the deck. Find (a) the acceleration of the puck, (b) the speed of the puck after the 2.00 s, (c) the horizontal distance from the table edge to where the puck impacts the deck.

$$F_{Net} = ma\,;\, a = \frac{F_{Net}}{m} = \frac{85.0N}{0.00345kg} = 2.46x10^4 m/s^2$$

$$v = v_o + at$$

$$v = at = (2.46x10^4 m/s^2)(1.10s) = 2.71x10^4 m/s$$

$$d_y = v_{yo}t + a_y t^2$$

$$d_y = a_y t^2\,;\, t = \sqrt{\frac{d_y}{a_y}} = \sqrt{\frac{-0.850m}{-9.8m/s^2}} = 0.295s$$

$$d_x = v_x t = (2.71x10^4 m/s)(0.295s) = 7.98x10^3 m$$