1) In a 'great leap forward', a frog of 0.5kg mass can kick back its legs with a total force that is three times of its body weight.
   a) How big is this 'leaping' force in Newtons?
   b) What is frog's instantaneous forward acceleration when it is on:
      b.1) A frictionless surface.
      b.2) A smooth surface that can only provide maximum static friction force of 5N.
      b.3) A rough surface that can provide maximum static friction force of 100N.

   a) \[ F = 3 \times w = 3 \times 0.5 \times 9.8 = 14.7 \text{ N} \]

   notice that 14.7 Newton is NOT the force acted on the frog!

   b.1) \[ f_s = 0 \quad a = 0 \text{ m/s}^2 \]

   b.2) \[ f_s = 5 \text{ N} \quad a = \frac{5}{0.5} = 10 \text{ m/s}^2 \]

   b.3) max \[ f_s = 100 \text{ N} \] but the frog can only kick with 14.7N

   \[ f_s = 14.7 \text{ N} \quad a = \frac{14.7}{0.5} = 29.4 \text{ m/s}^2 \]
2) A box of 40 kg is placed on a rough surface which is inclined by 27 degrees. The kinetic friction coefficient is 0.34, and the static coefficient is unknown.

a) It is observed that the box remains at rest. How big is the static frictional force?

b) A downhill force parallel to the incline is applied. If the static friction coefficient is 0.55, how big must be the force to cause the box to start to move downhill?

c) Once the box starts to move, the downhill force is removed. What is the acceleration of the box? Is the box speeding up or slowing down?

\[ F = 0 \quad a = 0 \]

so:

\[ mg \cos 27^\circ - f_s = 0 \]

\[ N + mg \sin 27^\circ = 0 \]

\[ \begin{cases} N = 349.3 \text{ N} \\ f_s = 178 \text{ N} \end{cases} \]

b) \[ F \neq 0, \quad a = 0, \quad f_s = f_s_{\text{max}} = 0.55 \times N = 192.1 \text{ N} \]

\[ F + mg \cos 27^\circ - 192.1 = 14 \text{ N} \]

c) \[ F = 0, \quad a \neq 0, \quad f_s \rightarrow f_k = 0.34 \times N = 118.8 \text{ N} \]

\[ mg \cos 27^\circ - 118.8 = ma = 40 a \]

\[ a = 1.48 \text{ m/s}^2 \]

speeding up!
3) A man drags a 7.2kg box 4.00m across the floor, exerting a constant force of 15.0N, directed 30 degree above the horizontal. The kinetic friction coefficient between the box and the floor is 0.14.
   a) Find the normal force of the floor acted on the box (not the weight of the box!).
   b) Find the work done by the applied force.
   c) How much work is done by the friction?
   d) Is the total work done on the box positive or negative?

\[ N + 15 \sin 30^\circ - 7.2 \times 9.8 = 0 \]
\[ N = 63.1 \text{ N} \]

\[ W = F \cdot s \cdot \cos 0 = 15 \times 4 \times \cos 30^\circ = 52 \text{ J} \]

\[ W = -f_k \cdot s = -0.14 \times 63.1 \times 4 = -35.3 \text{ J} \]

\[ 52 - 35.3 = 16.7 \text{ J} \quad \text{positive} \]
4) When sitting in a roller coaster going through a vertical loop of radius of 8.5 meters, your 'apparent' weight is the normal force provided by the seat, while your 'true' weight is the gravitational force (which is unluckily unchangeable at $mg$).

a) How fast must you be moving at the top of the vertical loop to achieve weightlessness (i.e., to have no apparent weight)?

b) If moving at the same speed on the bottom of the vertical loop, what is your apparent weight then?

\[ mg = m \frac{v^2}{R} \]
\[ v = \sqrt{Rg} = 9.13 \text{ m/s} \]

\[ N - mg = m \frac{v^2}{R} \]
\[ N = mg + m \frac{v^2}{R} = 2mg \]

2 x actual weight = apparent weight
5) The 0.4kg glider-A is moving to the right on a frictionless, horizontal air track with a speed of 1.75 m/s when it makes a head-on, elastic collision with the stationary 0.15kg glider-B.

a) After the collision, glider-B moves to the right at speed $v_B$. In term of $v_B$, what is the speed of the glider-A? HINT: for elastic collision, approaching speed always equals separation speed.

b) According to momentum conservation law, how fast is the glider-B after the collision?

c) Is glider-A, after the collision, moving to right or to left?

\[
\begin{align*}
A & \rightarrow \quad B \\
\quad \quad & \quad \\
A \cdot v_A & \rightarrow \quad B \rightarrow \quad v_B
\end{align*}
\]

a) 

**Approaching speed** 

\[ v_A = v_B - 1.75 \]

b) 

\[
0.4 \times (1.75) + 0.15 \times 0 = 0.4 \cdot v_A + 0.15 \cdot v_B \\
0.7 = 0.4 \cdot v_A + 0.15 \cdot v_B \\
0.7 = 0.4 (v_B - 1.75) + 0.15 \cdot v_B \\
1.4 = 0.55 v_B \\
\]

\[ v_B = 2.55 \text{ m/s} \]

c) 

\[ v_A = v_B - 1.75 = 2.55 - 1.75 = 0.80 \text{ m/s} \]

to RIGHT