1) The best rebounders in basketball have a vertical leap (that is, the vertical movement of a fixed point on their body) of about $120\,cm$.
(a) What is their initial "launch" speed off the ground? **(b)** How long are they in the air?

Choose ↑ be positive direction, $y_0 = 0$ floor level.

Upward path $y = 1.20\text{ m}$, $v = 0$ at the top. $a = -9{,}80\text{ m/s}^2$

(a) $v^2 = v_0^2 + 2a(y - y_0)$

$$v_0 = \left[v^2 - 2a(y-y_0)\right]^{1/2} = \left[-2ay\right]^{1/2} = \sqrt{-2(-9{,}80)1.20} = \boxed{4.85\text{ m/s}}$$

(b) $y = y_0 + v_0 t + \frac{1}{2}at^2 = 0 \rightarrow t\left(v_0 + \frac{1}{2}at\right) = 0$

$$t = 0,\quad t = \frac{2v_0}{-a} = \frac{2 \cdot 4.85}{-2(-9{,}80)} = \boxed{0.99\text{ s}}$$

2) You buy a plastic dart gun, and being a clever physics student you decide to do a quick calculation to find its maximum horizontal range. You shoot the gun straight up, and it takes $4.0\,s$ for the dart to land back at the barrel. What is the maximum horizontal range of your gun?

When shooting the gun vertically, half flight time is spent moving upwards.
Thus the upwards flight takes 2.0 s.

Choose upwards as +y-direction.

$$v_y = v_{y_0} + at \rightarrow v_{y_0} = v_y - at = 0 - (-9{,}80)\,2.0 = 19{,}6\text{ m/s}$$

Use this initial velocity and angle 45° in the range formula:

$$R = \frac{v_0^2 \sin(2\theta)}{g} = \frac{19{,}6^2 \sin 90°}{9{,}80}$$

$$\boxed{R = 39\text{ m}}$$

3)

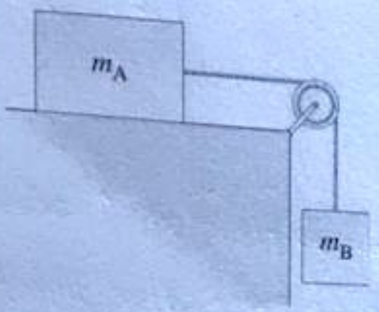
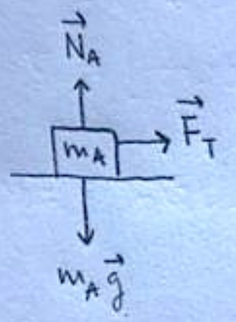


Figure shows a block (mass m_A) on a smooth horizontal surface, connected by a thin cord that passes over a pulley to a second block m_B which hangs vertically. **(a)** Draw a free-body diagram for each block, showing the force of gravity on each, the force (tension) exerted by the cord, and any normal force. **(b)** Apply Newton's second law to find formulas for the acceleration of the system and for the tension in the cord in terms of m_A, m_B and g.
(Ignore friction and the masses of the pulley and cord.)

(a)



(b) For mass A:

$$\sum F_y = N_A - m_A g = 0 \rightarrow N_A = m_A g$$

$$\sum F_x = F_T = m\, a_{Ax}$$

For mass B:

$$\sum F_y = F_T - m_B g = -m_B a_{By}$$

Since they are connected $\rightarrow a_{Ax} = a_{By} = a$

Then,

$$F_T = m_A a$$

$$m_B g - F_T = m_B a \rightarrow m_B g - m_A a = m_B a$$

$$m_B g = m_A a + m_B a$$

$$\downarrow$$

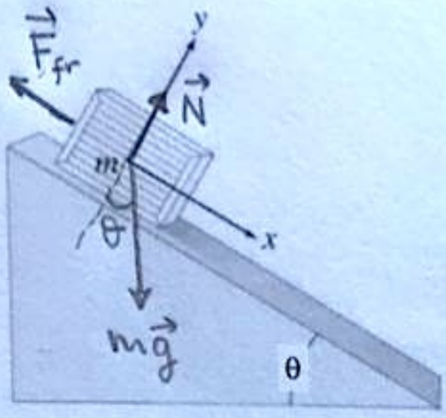
$$\boxed{a = g \frac{m_B}{m_A + m_B}}$$

Put this in F_T

$$F_T = m_A a$$

$$\boxed{F_T = g \frac{m_A m_B}{m_A + m_B}}$$

4)



The box shown in the Figure lies on a plane tilted at an angle $\theta = 25.0^{\circ}$ to the horizontal, with a kinetic friction coefficient $\mu_k = 0.19$.

(a) Determine the acceleration of the box as it slides down the plane.

(b) If the box starts from rest $8.15\,m$ up the plane from its base, what will be the speed of the box when it reaches the bottom of the incline?

From Newton's 2nd law:

(a) $\sum F_y = \vec{N} - mg\cos\theta = 0 \rightarrow N = mg\cos\theta$

$\sum F_x = mg\sin\theta - F_{fr} = ma \rightarrow ma = mg\sin\theta - \mu_k N$

$ma = mg\sin\theta - \mu_k mg\cos\theta$

$a = g(\sin\theta - \mu_k\cos\theta)$

$= 9.80(\sin 25 - 0.19\cos 25)$

$\boxed{a = 2.45\ m/s^2}$

(b) $v^2 - v_0^2 = 2a(x - x_0)$

$v = \sqrt{2a(x - x_0)}$

$= \sqrt{2 \cdot 2.45\,(8.15 - 0)}$

$\boxed{v = 6.3\ m/s}$

5) On an ice rink, two skaters of equal mass grab hands and spin in a mutual circle once every $2.5\,s$. If we assume their arms are each $0.80\,m$ long (namely, radius of the circle is $r = 0.80\,m$) and their individual masses are $60.0\,kg$, how much force are they exerting on one another?

The radius of each skater is 0.80m, period is 2.5s.

$v = \frac{2\pi r}{T} = \frac{2\pi\, 0.80}{2.5\,s} = 2.0\ m/s$

Radial force $F = \frac{mv^2}{r} = \frac{60.0\,(2.0)^2}{0.80} = \boxed{3.0 \times 10^2\ N}$