# Tutorial Oct. 2

3.54

rock A

$$v_y^A(t) = -gt$$

$$y^A(t) = h - \frac{g}{2}t^2$$

rock B

$$v_y^B(t) = v_0 - gt$$

$$y^B(t) = h + v_0 t - \frac{g}{2}t^2$$

$$h = 150\ m$$

step 1: when does rock A hit the ground?

$$y^A(t_{gr}) = 0 = h - \frac{g}{2}t_{gr}^2$$

$$\Leftrightarrow \quad t_{gr} = \sqrt{\frac{2h}{g}} = 5.53\ s$$

step 2: now consider rock B

$$y^B(t = t_{gr} - 1) = 0$$

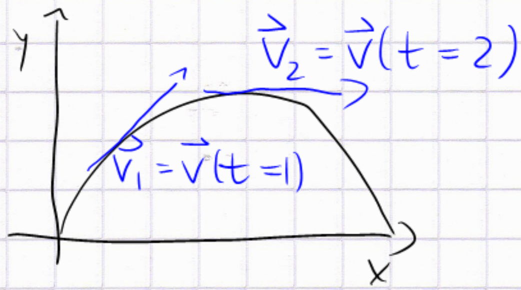
$$\Leftrightarrow \quad h + v_0(t_{gr} - 1) - \frac{g}{2}(t_{gr} - 1)^2 = 0$$

$$\Leftrightarrow \quad v_0 = \frac{g}{2}(t_{gr} - 1) - \frac{h}{t_{gr} - 1} = -11\ m/s$$

ball is thrown downwards!

# Planet Exidar

(1)




(2) Acceleration

$$m\vec{a} = \vec{F}_{net} = \vec{F}_{grav}$$

$\hat{i}$: $a_x = \dfrac{F_x}{m} = 0$

$\hat{j}$: $a_y = \dfrac{F_y}{m} = -g$

$\Rightarrow \vec{a} = 0\hat{i} - g\hat{j}$

(3) show $\vec{v}(t) = v_0 \cos\theta\, \hat{i} + (v_0 \sin\theta - gt)\hat{j}$

(a) $\vec{v}(t=0) = v_0 \cos\theta\, \hat{i} + v_0 \sin\theta\, \hat{j} = \vec{v}_0$ ✓

(b) $\dfrac{d}{dt}\vec{v}(t) = 0\hat{i} - g\hat{j} = \vec{a}$ ✓

(4) Determine $g, \theta, v_0$ from:

$$\left| \begin{aligned} v_x(t=1) &= 2 = v_0 \cos\theta & (1)\\ v_y(t=1) &= 2 = v_0 \sin\theta - g & (2)\\ v_y(t=2) &= 0 = v_0 \sin\theta - 2g & (3) \end{aligned} \right.$$

(in SI units)

(2'): $v_0 \sin\theta = 2 + g$
(3'): $v_0 \sin\theta = 2g$

$\Big\}\quad 2 + g = 2g \iff g = 2\ m/s^2$

(3') and (1):

$$\frac{\cancel{v_0}\sin\theta}{\cancel{v_0}\cos\theta} = \frac{\cancel{2}g}{\cancel{2}} = g$$

$\iff \tan\theta = 2,\quad \theta = 63°$

(1): $v_0 = \dfrac{2}{\cos\theta} = 4.5\ m/s$

(5) If the ball reaches maximum height at $t = 2s$ it reaches the ground at $t = 4s$.

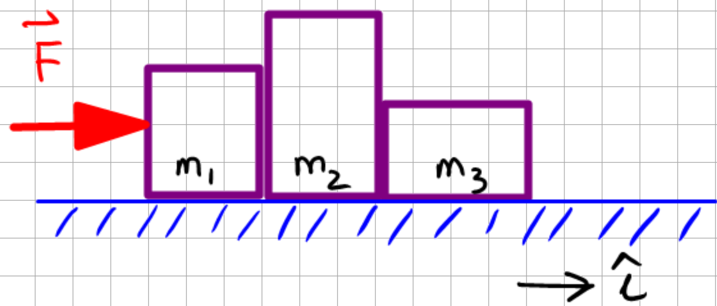
Condition: $y(t_{gr}) \overset{!}{=} 0$

$$\Leftrightarrow \quad V_0 t_{gr} \sin \theta - \frac{g}{2} t_{gr}^2 = 0$$

$$\Leftrightarrow \quad t_{gr} = \frac{2 V_0 \sin \theta}{g} = 4s$$

(6) Range $\Delta x = V_0 t_{gr} \cos \theta = 80 \text{ m}$

Pushing crates: normal forces; no friction (3.36) 




the combined system accelerates due to $\vec{F} = F\hat{\imath}$

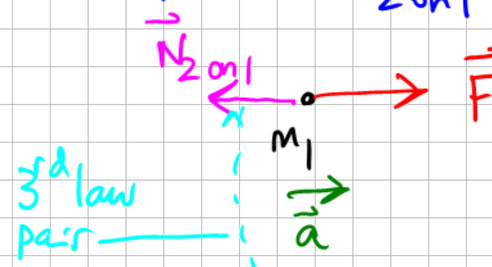
(1) $F = (m_1 + m_2 + m_3)\,a$

The vertical forces cancel, e.g., $m_1 g = N_{\text{floor on }1}$

Look at $m_1$: - it also accelerates with $a$
- the net force acting on it has to be less than $F$!

Since $m_1$ exerts a normal force to the right, on $m_2$, $\vec{N}_{1\,on\,2}$ there is an action-reaction partner force: $\vec{N}_{2\,on\,1}$.

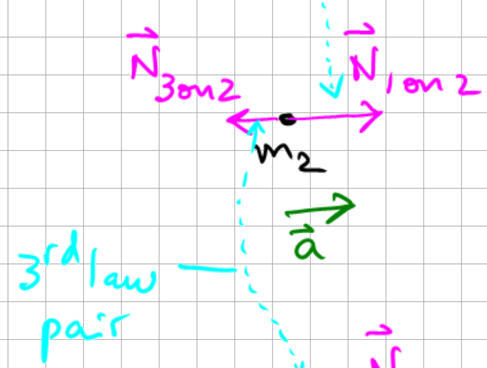
The free-body diagram for $m_1$:




(2) $m_1 a = F - N_{2\,on\,1}$

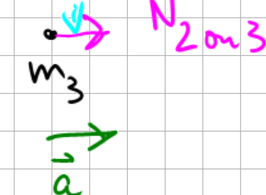
a magnitude, the "$-$" sign gives direction

Now the FB diagram for $m_2$:




(3) $m_2 a = N_{1\,on\,2} - N_{3\,on\,2}$

and for $m_3$:




(4) $m_3 a = N_{2\,on\,3}$

The third law states for the magnitudes:

$N_{1\,on\,2} = N_{2\,on\,1} \; (= N_{12})$

$N_{2\,on\,3} = N_{3\,on\,2} \; (= N_{23})$

The three FB diagrams are consistent with acceleration $\vec{a}$ for each mass!

Use Eq. (1) to calculate $m_2$:

$$m_2 = \frac{F}{a} - m_1 - m_3 = 8.3\ \text{kg}$$

Use Eq (4) to calculate $N_{2\,on\,3} = N_{3\,on\,2}$

$$m_3\, a = N_{2\,on\,3} = 50\ \text{N}$$