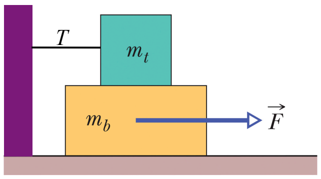
Example

The top block is attached to a wall by a string. If $F = 30$ N, $m_t = 5.0$ kg, $m_b = 10.0$ kg, and the coefficient of kinetic friction is 0.10 between all surfaces, what is the tension in the string, and the acceleration of the bottom block?



Projectile motion revisited

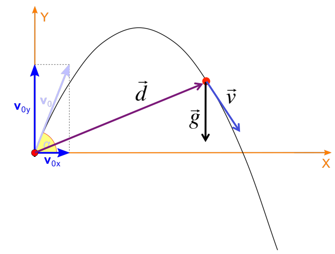
Kinematic approach:

$\sum F_x = 0 \quad \therefore v_x = v_{0x}$

$\sum F_y = -mg = ma_y \quad \therefore a_y = -g$

$\therefore v_y^2 = v_{0y}^2 - 2g\Delta y$

$$v^2 = v_x^2 + v_y^2 = v_{0x}^2 + v_{0y}^2 - 2g\Delta y = v_0^2 - 2g\Delta y$$

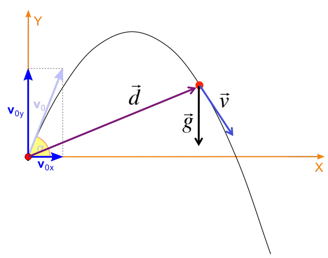


Projectile motion revisited

Work-energy approach:

$\vec{F} = m\vec{g} = -mg\hat{j}$

$\vec{d} = \Delta x\hat{i} + \Delta y\hat{j}$



Work done by gravity:

$W_g = \vec{F}\cdot\vec{d} = -mg\Delta y$

$\Delta K = W_g \quad \therefore \tfrac{1}{2}mv^2 - \tfrac{1}{2}mv_0^2 = -mg\Delta y$

$\therefore v^2 = v_0^2 - 2g\Delta y$

Particle on a **frictionless** ramp of arbitrary shape:

$\Delta K = W = \int_{\vec{r}_i}^{\vec{r}_f} \vec{F}\cdot d\vec{r} \qquad \vec{F} = \vec{F}_N + \vec{F}_g$, but $\vec{F}_N \perp d\vec{r}$ all along the path

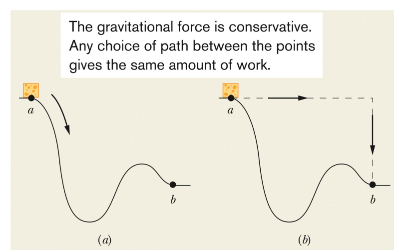
Therefore the normal force F_N does **no work**, so only F_g does work.

$\Delta K = W_g = -mg\Delta y$

$\tfrac{1}{2}mv^2 - \tfrac{1}{2}mv_0^2 = -mg\Delta y$

$\therefore v^2 = v_0^2 - 2g\Delta y$

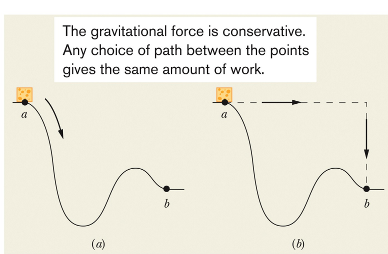
independent of path!



Can also view this using **conservation of mechanical energy** concept.

$\Delta U = -W = mg\Delta y \qquad \therefore \Delta K = -\Delta U$ or $\Delta K + \Delta U = 0$

Equivalently, $E = K_a + U_a = K_b + U_b \qquad$ (*i.e.* $\Delta E = 0$)

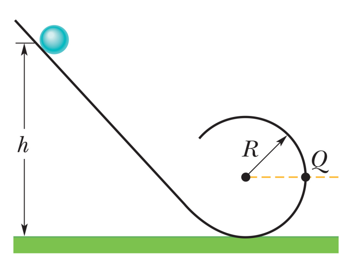


Problem 11.12

A solid ball of radius b rolls smoothly along a loop-the-loop. It is released from rest at a height h above the ground. The circular loop has radius $R = 14.0$ cm (we assume b is much smaller than R).

What is h if the ball is just on the verge of leaving the track at the top of the loop?

Answer: $h = 2.7\,R$



Problem 11.39

A flywheel has a moment of inertia of 0.140 kg-m^2 about its central axis. The angular momentum decreases from 3.00 to 0.800 kg-m^2/s in 1.50 s.

(a) What is the magnitude of the average torque acting **on** the flywheel? τ_{avg} = -1.47 N-m

(b) If the angular acceleration is constant, through what angle does the flywheel turn? $\Delta\theta$ = 20.4 rad

(c) How much work is done **on** the wheel by the torque? -30 J

(d) What is the average power delivered **by** the flywheel? 20 W

2009 #8

8. An ideal spring is hung vertically from the ceiling. When a 3.0-kg mass hangs at rest from it, the spring is extended 0.06 m from its relaxed length. A downward external force is now applied to the mass to extend the spring an additional 0.1 m. While the spring is being extended by the force, the work done by the spring is:

(a) –8.7 J (b) $\boxed{\text{–5.4 J}}$ (c) –5.4 × 10^{-4} J (d) -540 J (e) 2.5 J

2012 #14

A 0.50 kg block attached to an ideal spring with a spring constant of 80 N/m oscillates on a horizontal frictionless surface. When the spring is 4.0 cm longer than its equilibrium length, the speed of the block is 0.50 m/s.

What is the maximum speed of the block? 0.71 m/s