# RECITATION 7

## Ch. 8

••8 A 1.50 kg snowball is fired from a cliff 12.5 m high. The snowball's initial velocity is 14.0 m/s, directed 41.0° above the horizontal. (a) How much work is done on the snowball by the gravitational force during its flight to the flat ground below the cliff? (b) What is the change in the gravitational potential energy of the snowball–Earth system during the flight? (c) If that gravitational potential energy is taken to be zero at the height of the cliff, what is its value when the snowball reaches the ground?

a)

$$W_g = mg(y_i - y_f) = (1.50\ \text{kg})(9.81\ \text{m/s}^2)(12.5\ \text{m} - 0) = 184\ \text{J}.$$

b)

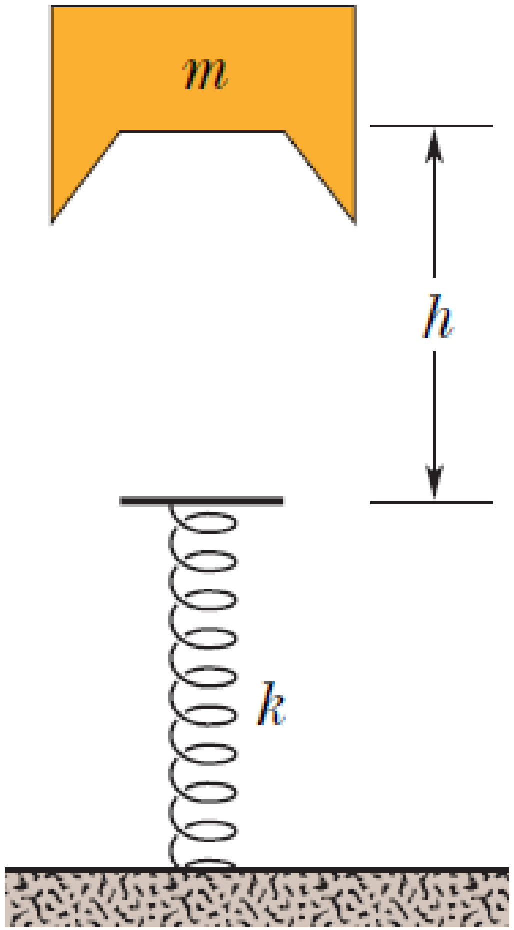
$$\Delta U_g = -W_g = -184\ \text{J}.$$

c)

$$\Delta U_g = U_{gf} - U_{gi} = U_{gf} - 0 = -184\ \text{J}.$$

$$U_{gf} = -184\ \text{J}.$$

**••24** A block of mass $m = 2.0$ kg is dropped from height $h = 40$ cm onto a spring of spring constant $k = 1960$ N/m (Fig. 8-37). Find the maximum distance the spring is compressed.



$$\Delta U_g + \Delta U_s = 0$$

$$mg\left(Y_f - Y_i\right) + \frac{1}{2}k\left(y_f^2 - y_i^2\right) = 0$$

Let's take $y_i = 0$ and $y_f = -d$, where $d$ is the distance by which the spring is compressed. Then $Y_i = h$ and $Y_f = -d$. Thus,

$$mg(-d - h) + \frac{1}{2}k(d^2 - 0) = 0.$$

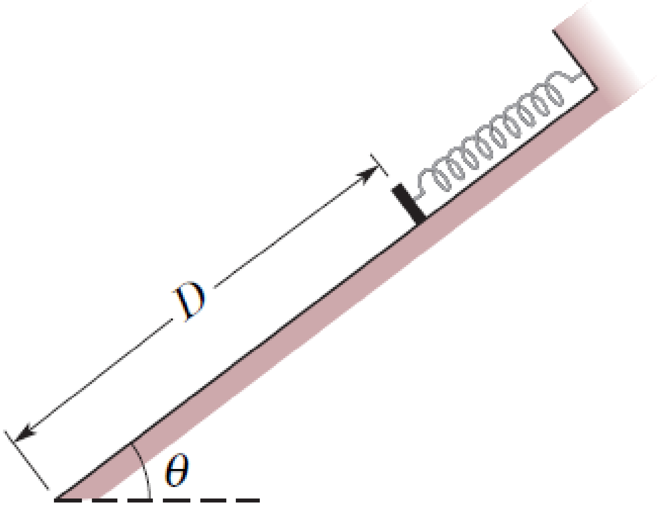
Solving for $d$

$$d = \frac{mg + \sqrt{m^2g^2 + 2mgkh}}{k}$$

$$= \frac{(2.0\ \mathrm{kg})\left(9.8\,\frac{\mathrm{m}}{\mathrm{s}^2}\right) + \sqrt{(2.0\ \mathrm{kg})^2\left(9.8\,\frac{\mathrm{m}}{\mathrm{s}^2}\right)^2 + 2(2.0\ \mathrm{kg})\left(9.8\,\frac{\mathrm{m}}{\mathrm{s}^2}\right)\left(1960\,\frac{\mathrm{N}}{\mathrm{m}}\right)(0.40\ \mathrm{m})}}{1960\,\frac{\mathrm{N}}{\mathrm{m}}}$$

$$= 0.10\ \mathrm{m}.$$

•••33 GO In Fig. 8-44, a spring with $k = 170$ N/m is at the top of a frictionless incline of angle $\theta = 37.0°$. The lower end of the incline is distance $D = 1.00$ m from the end of the spring, which is at its relaxed length. A 2.00 kg canister is pushed against the spring until the spring is compressed 0.200 m and released from rest. (a) What is the speed of the canister at the instant the spring returns to its relaxed length (which is when the canister loses contact with the spring)? (b) What is the speed of the canister when it reaches the lower end of the incline?



a)

$$\Delta E_{\text{mec}} = 0$$

$$\Delta U_g + \Delta U_s + \Delta K = 0$$

$$mg(h_f - h_i) + \frac{1}{2}k(x_f^2 - x_i^2) + \frac{1}{2}m(v_f^2 - v_i^2) = 0 \ (1)$$

We have that $h_i = (D + x)\sin\theta$ , $h_f = D\sin\theta$ and thus $h_f - h_i = -x\sin\theta = -0.200\sin 37.0° = -0.120\ \text{m}$. Also, $x_i = -x = -0.200\ \text{m}$, $x_i = 0$ and $v_i = 0$.

Substituting in Eq. (1) gives,

$$(2.00\ \text{kg})\left(9.81\frac{\text{m}}{\text{s}^2}\right)(-0.120\ \text{m}) + \frac{1}{2}\left(170\frac{\text{N}}{\text{m}}\right)[0 - (-0.200\ \text{m})^2] + \frac{1}{2}(2.00\ \text{kg})\left(v_f^2 - 0\right) = 0.$$

Solving gives $v_f = 2.40\ \text{m/s}$.

b)

In this case $h_i = (D + x)\sin\theta$ , $h_f = 0$ and thus $h_f - h_i = -(D + x)\sin\theta = -1.200\sin 37.0° = -0.722\ \text{m}$. Substituting in Eq. (1) gives and solving for $v_f$ gives that $v_f = 4.19\ \text{m/s}$.

**••54** A child whose weight is 267 N slides down a 6.1 m playground slide that makes an angle of 20° with the horizontal. The coefficient of kinetic friction between slide and child is 0.10. (a) How much energy is transferred to thermal energy? (b) If she starts at the top with a speed of 0.457 m/s, what is her speed at the bottom?

a)

$$\Delta E_{\text{th}} = f_k d = \mu F_N d$$

$$F_N = F_g \cos 20° = (267\text{ N}) \cos 20° = 251\text{ N}.$$

$$\Delta E_{\text{th}} = \mu F_n d = (0.10)(251\text{ N})(6.1\text{ m}) = 150\text{ J}.$$

b)

$$\Delta E_{\text{mec}} + \Delta E_{\text{th}} = 0.$$

$$\Delta U_g + \Delta K + \Delta E_{\text{th}} = 0$$

$$K_f = K_i - \Delta U_g - \Delta E_{\text{th}}$$

$$\Delta U_g = mg\left(h_f - h_i\right) = F_g\left(h_f - h_i\right) = (267\ \text{N})(0 - 6.1\sin 20°)$$

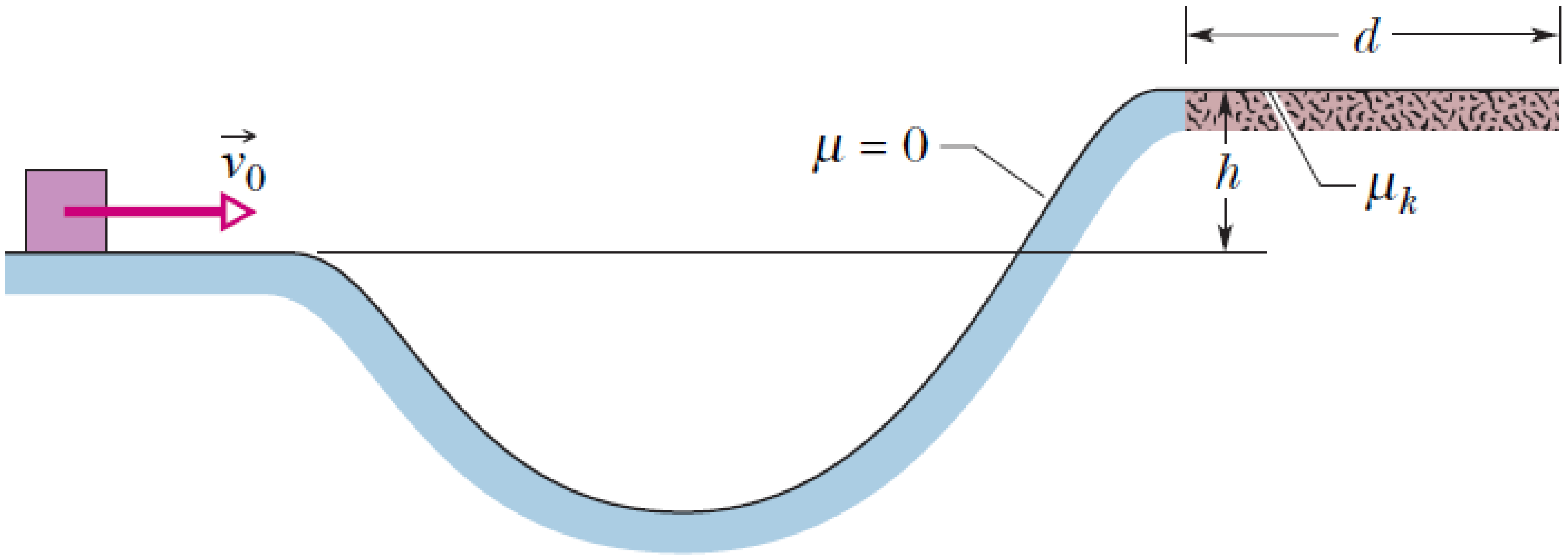
$$= -557\ \text{J}.$$

$$K_i = \frac{1}{2}mv_i^2 = \frac{1}{2}\left(\frac{267\ \text{N}}{9.81\,\frac{\text{m}}{\text{s}^2}}\right)\left(0.457\,\frac{\text{m}}{\text{s}}\right)^2 = 2.84\,\frac{\text{m}}{\text{s}}.$$

$$K_f = 2.84\,\frac{\text{m}}{\text{s}} - (-557\ \text{J}) - 153\ \text{J} = 407\ \text{J}.$$

$$v_f = \sqrt{\frac{2K_f}{m}} = \sqrt{\frac{2(407\ \text{J})}{\frac{267\text{N}}{9.81\text{m/s}^2}}} = 5.5\ \text{m/s}.$$

••57 In Fig. 8-52, a block slides along a track from one level to a higher level after passing through an intermediate valley. The track is frictionless until the block reaches the higher level. There a frictional force stops the block in a distance $d$. The block's initial speed $v_0$ is 6.0 m/s, the height difference $h$ is 1.1 m, and $\mu_k$ is 0.60. Find $d$.



$$\Delta E_{\text{mec}} + \Delta E_{\text{th}} = 0.$$

$$\Delta U_g + \Delta K + \Delta E_{\text{th}} = 0 \ (2)$$

$$\Delta K = \frac{1}{2}m\left(v_f^2 - v_i^2\right) = -\frac{1}{2}mv_i^2$$

$$\Delta U_g = mg\left(h_f - h_i\right) = mg(h - 0) = mgh$$

$$\Delta E_{\text{th}} = f_K d = \mu_k F_N d = \mu_k mgd$$

Substituting in (2) yields

$$mgh + \left(-\frac{1}{2}mv_i^2\right) + \mu_k mgd = 0$$

$$d = \frac{v_i^2 - 2gh}{2\mu_k g} = \frac{(6.0\ \text{m/s})^2 - 2(9.8\ \text{m/s}^2)(1.1\ m)}{2(0.60)(9.8\ \text{m/s}^2)} = 1.2\ \text{m}.$$