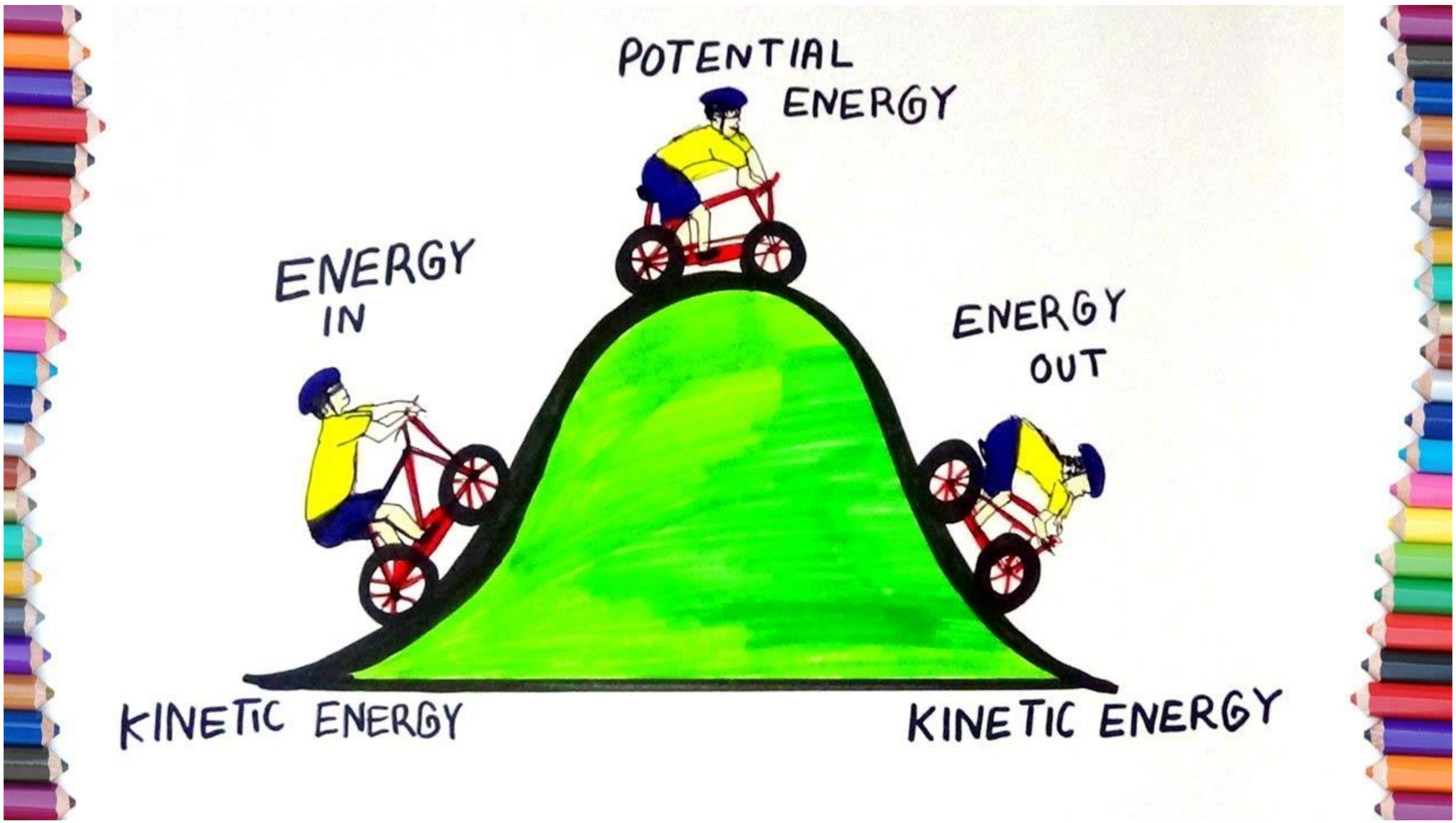
06 Energi Potensial dan Konservasi Energi

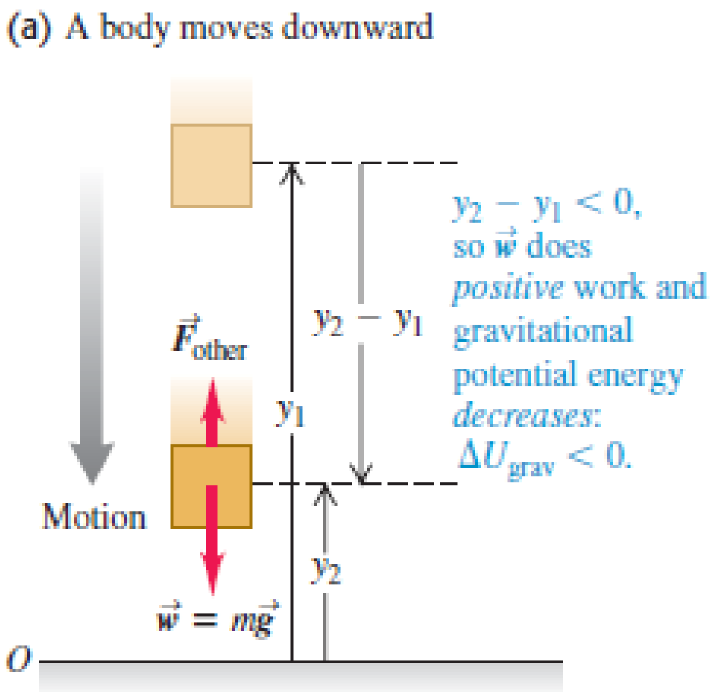

POTENTIAL ENERGY
ENERGY IN
ENERGY OUT
KINETIC ENERGY
KINETIC ENERGY

Energi Potensial

- Energi yang dimiliki oleh obyek (tersimpan di dalam obyek) karena posisi relatif dengan obyek lain, tekanan di dalam obyek tersebut, muatan elektrik atau faktor – faktor lain

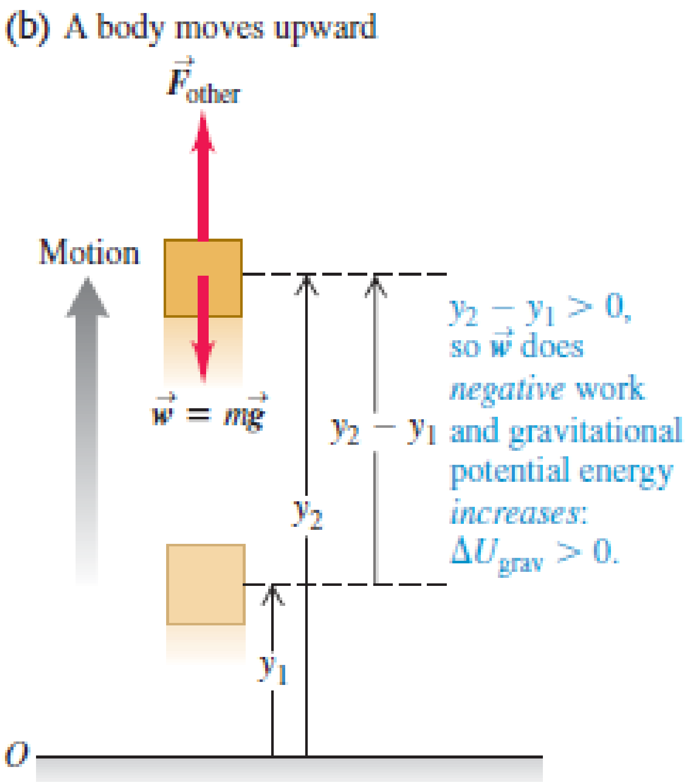
Tipe umum energi potensial

1. Energi potensial gravitasi suatu obyek yang tergantung pada massa dan jarak dari pusat massa tersebut dengan obyek lain
2. Energi potensial elastik dari spring (per) yang ditarik
3. Energi potensial listrik suatu muatan listrik dalam suatu medan listrik



- Sebuah obyek bergerak ke lurus vertikal ke turun.
- Gaya yang bekerja adalah gaya berat w = mg dan gaya lain ke atas yang kita sebut F_{other}
- Berat dan perpindahan arah yang sama

$$W_{grav} = Fs = w(y_1 - y_2) = mgy_1 - mgy_2$$



- Persamaan berlaku untuk gerak ke atas
- y2 > y1
- Wgrav akan negatif jika arah perpindahan berlawanan dengan arah gaya

- Kuantitas berat mg dan tinggi y pada titik asal koordinat disebut energi potensial gravitasi

$$U_{grav} = mgy \qquad \text{(gravitational potential energy)}$$

- Titik asal 1
- Titik akhir 2
- Perubahan energi sama dengan

$$U_{grav,1} = mgy_1$$

$$U_{grav,2} = mgy_2.$$

$$\Delta U_{grav} = U_{grav,2} - U_{grav,1}$$

$$W_{\mathrm{grav}} = U_{\mathrm{grav},1} - U_{\mathrm{grav},2} = -(U_{\mathrm{grav},2} - U_{\mathrm{grav},1}) = -\Delta U_{\mathrm{grav}}$$

- Nilai negatif ini penting.
- Ketika obyek bergerak ke atas, nilai y naik, kerja yang dilakukan oleh gaya gravitasi negatif, dan energi potensial gravitasi naik
- Ketika obyek bergerak ke bawah, nilai y turun, gaya gravitasi positif, dan enegi potensial gravitasi turun.

Energi Potensial Elastis

$$\Delta U = -\int_{x_i}^{x_f} (-kx)\, dx = k \int_{x_i}^{x_f} x\, dx = \tfrac{1}{2}k\left[x^2 \right]_{x_i}^{x_f},$$

$$\Delta U = \tfrac{1}{2}kx_f^2 - \tfrac{1}{2}kx_i^2.$$

Konservasi Energi Mekanik (hanya gaya gravitasi)

$$K_1 + U_{grav,1} = K_2 + U_{grav,2}$$

$$\frac{1}{2}mv_1^2 + mgy_1 = \frac{1}{2}mv_2^2 + mgy_2$$

Jumlah total energi K + U_{grav} disebut E, yaitu total energi mekanik sistem

$$E = K + U_{grav} = \text{constant}$$

Contoh:

- Sebuah obyek jatuh dari ketinggian 8,5 m. Dengan mengabaikan faktor friksi, tentukan kecepatan obyek sesaat sebelum jatuh

$$E_{\text{mec},b} = E_{\text{mec},t}.$$

To show both kinds of mechanical energy, we have

$$K_b + U_b = K_t + U_t,$$

or

$$\tfrac{1}{2}mv_b^2 + mgy_b = \tfrac{1}{2}mv_t^2 + mgy_t.$$

Dividing by m and rearranging yield

$$v_b^2 = v_t^2 + 2g(y_t - y_b).$$

Putting $v_t = 0$ and $y_t - y_b = h$ leads to

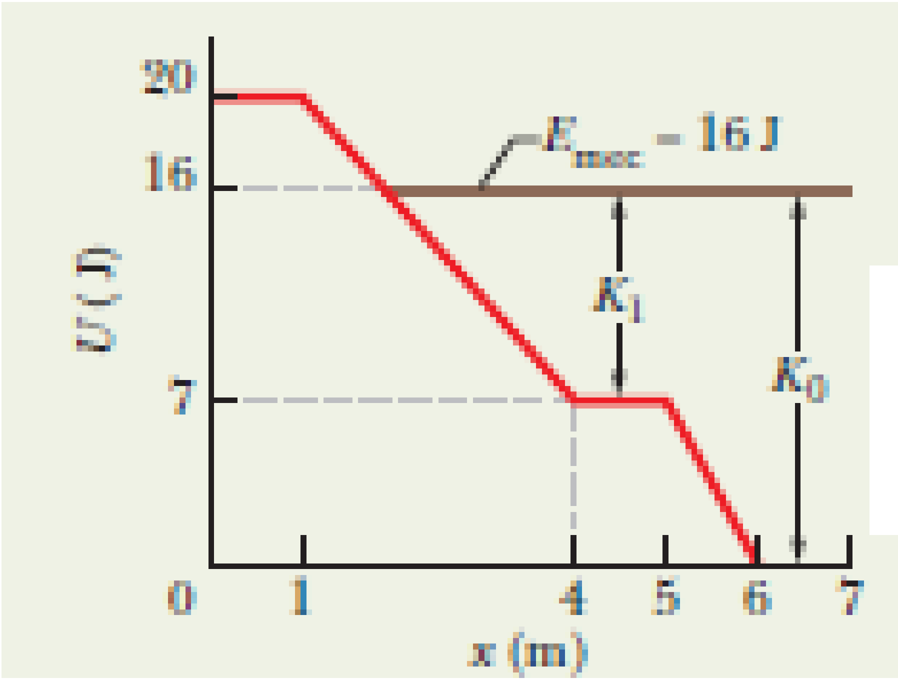
$$v_b = \sqrt{2gh} = \sqrt{(2)(9.8\ \text{m/s}^2)(8.5\ \text{m})}$$
$$= 13\ \text{m/s}.$$

Contoh 2

Sebuah obyek 2 kg bergerak sepanjang sumbu x dalam gerak 1 dimensi, ketika gaya konservatif mengenai obyek tersebut. Energi potensial U(x) diplotkan pada gambar, untuk obyek antara x = 0 dan x = 7 m. Kecepatan obyek v = -4 m/detik pada x = 6.5 m

a) Tentukan kecepatan pada x = 4.5 m!

b) Di mana titik obyek berbalik (diam sesaat) ?



Calculations: At $x = 6.5$ m, the particle has kinetic energy

$$K_0 = \tfrac{1}{2}mv_0^2 = \tfrac{1}{2}(2.00\text{ kg})(4.00\text{ m/s})^2$$
$$= 16.0\text{ J}.$$

Because the potential energy there is $U = 0$, the mechanical energy is

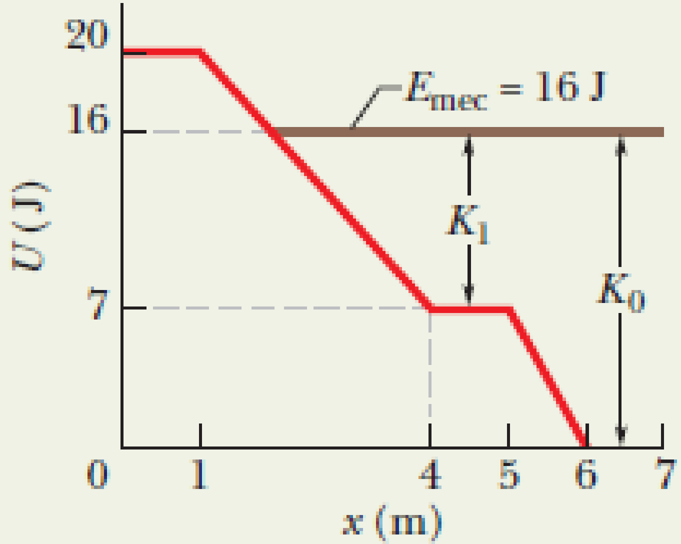
$$E_{\text{mec}} = K_0 + U_0 = 16.0\text{ J} + 0 = 16.0\text{ J}.$$

This value for E_{mec} is plotted as a horizontal line in Fig. 8-10*a*. From that figure we see that at $x = 4.5$ m, the potential energy is $U_1 = 7.0$ J. The kinetic energy K_1 is the difference between E_{mec} and U_1:

$$K_1 = E_{\text{mec}} - U_1 = 16.0\text{ J} - 7.0\text{ J} = 9.0\text{ J}.$$

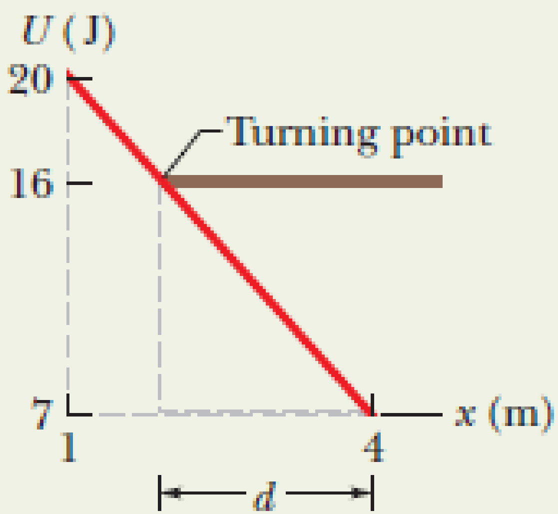
Because $K_1 = \tfrac{1}{2}mv_1^2$, we find

$$v_1 = 3.0\text{ m/s}. \qquad \text{(Answer)}$$



(a)

Kinetic energy is the difference between the total energy and the potential energy.



The kinetic energy is zero at the turning point (the particle speed is zero).

Contoh 3

- Sebuah benda meluncur pada jalur lengkung yang merupakan kuadran sebuah lingkaran dengan jari-jari R. Jika benda mulai bergerak dari keadaan diam dan tidak ada gesekan, tentukan kecepatan di dasar jalur tersebut.

Kerja

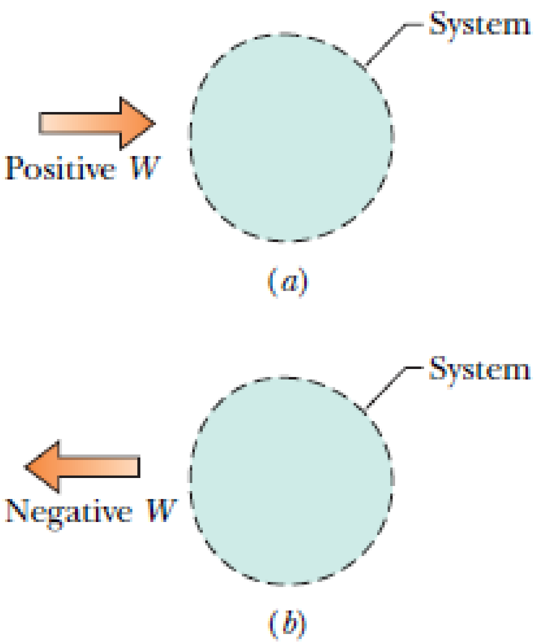


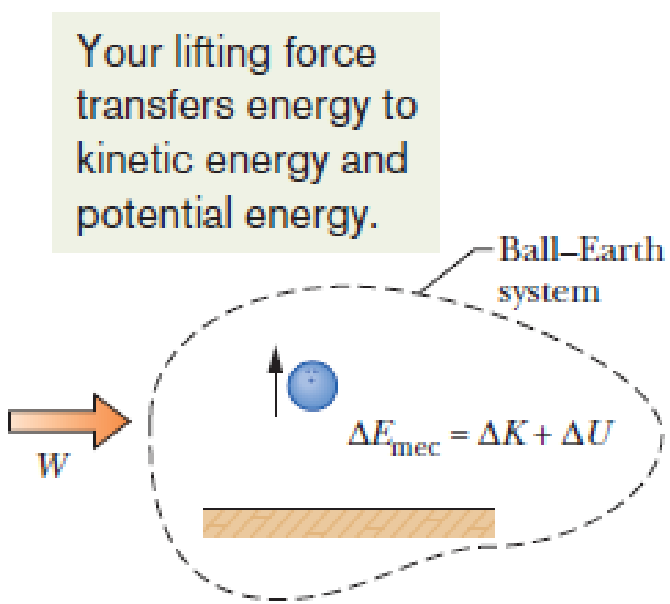
Fig. 8-11 (*a*) Positive work *W* done on an arbitrary system means a transfer of energy to the system. (*b*) Negative work *W* means a transfer of energy from the system.

- Kerja adalah energi yang ditransfer ke atau dari sistem dengan peralatan gaya eksternal terhadap sistem

- Friksi diabaikan

$$W = \Delta K + \Delta U,$$

$$W = \Delta E_{mec} \qquad \text{(work done on system, no friction involved),}$$



- Friksi diperhitungkan

The applied force supplies energy. The frictional force transfers some of it to thermal energy.

So, the work done by the applied force goes into kinetic energy and also thermal energy.

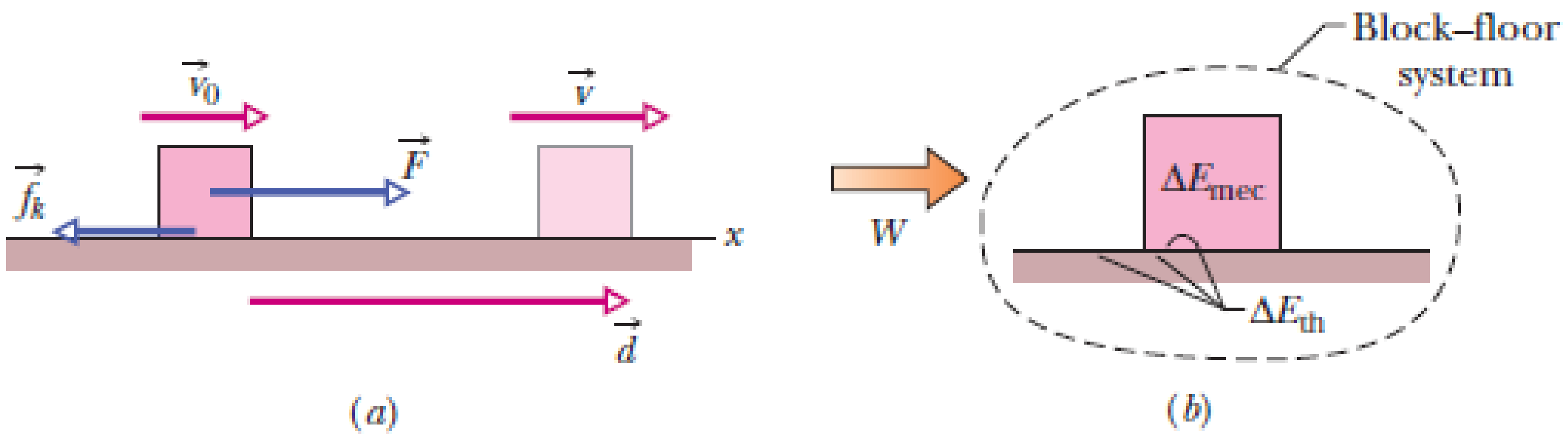


Fig. 8-13 (*a*) A block is pulled across a floor by force $\vec{F}$ while a kinetic frictional

$$F - f_k = ma. \tag{8-27}$$

Because the forces are constant, the acceleration $\vec{a}$ is also constant. Thus, we can use Eq. 2-16 to write

$$v^2 = v_0^2 + 2ad.$$

Solving this equation for a, substituting the result into Eq. 8-27, and rearranging then give us

$$Fd = \tfrac{1}{2}mv^2 - \tfrac{1}{2}mv_0^2 + f_k d \tag{8-28}$$

or, because $\frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 = \Delta K$ for the block,

$$Fd = \Delta K + f_k d. \tag{8-29}$$

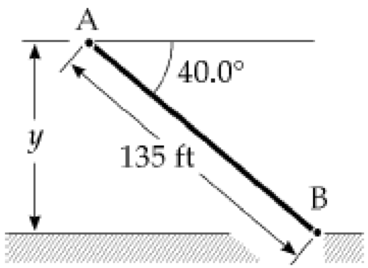
In a more general situation (say, one in which the block is moving up a ramp), there can be a change in potential energy. To include such a possible change, we generalize Eq. 8-29 by writing

$$Fd = \Delta E_{\text{mec}} + f_k d. \tag{8-30}$$

Sebuah benda 1000 kg mula-mula berada di puncak (titik A). Benda tersebut bergerak 135 ft pada sudut 40^o terhadap bawah horisontal ke titik lebih rendah B.

a) Dengan memilih titik B sebagai level nol terhadap energi potensial gravitasi, tentukan energi potensial benda pada titik A dan B

b) Ulangi pertanyaan a) jika level nol terhadap energi potenial gravitasi adalah A



$$U_A = mgy$$

where y is the vertical height above zero level. With $135\ \text{ft} = 41.1\ \text{m}$, this height is found as:

$$y = (41.1\ \text{m})\sin 40.0° = 26.4\ \text{m}.$$

Thus,

$$U_A = (1\,000\ \text{kg})\left(9.80\ \text{m/s}^2\right)(26.4\ \text{m}) = \boxed{2.59\times10^5\ \text{J}}.$$

The change in potential energy as the car moves from A to B is

$$U_B - U_A = 0 - 2.59\times10^5\ \text{J} = \boxed{-2.59\times10^5\ \text{J}}.$$

Obyek 400 N diayun pada tali panjang 2 m.

a) Tentukan energi potensial grafitasi posisi terendah.

b) Tentukan energi potensial grafitasi pada saat tali membentuk 30^o dengan vertikal.

(a) We take the zero configuration of system potential energy with the child at the lowest point of the arc. When the string is held horizontal initially, the initial position is 2.00 m above the zero level. Thus,

$$U_g = mgy = (400\ \text{N})(2.00\ \text{m}) = \boxed{800\ \text{J}}.$$

(b) From the sketch, we see that at an angle of 30.0° the child is at a vertical height of $(2.00\ \text{m})(1-\cos 30.0°)$ above the lowest point of the arc. Thus,

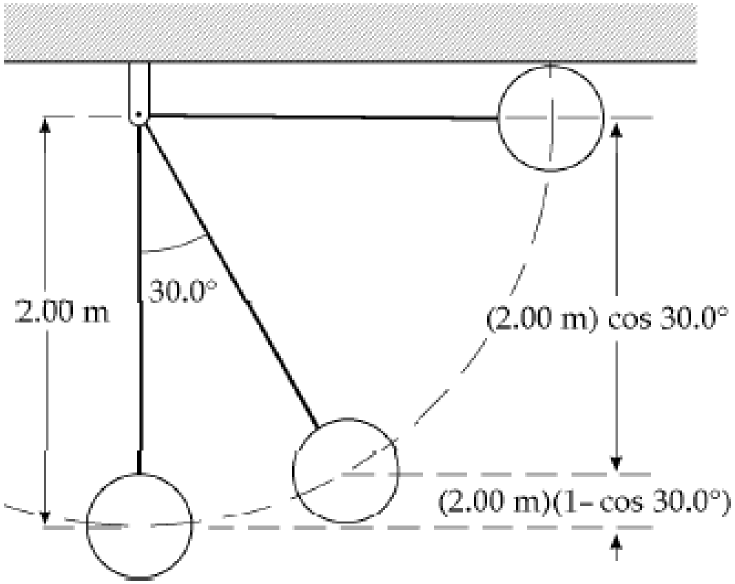


FIG. P8.2

$$U_g = mgy = (400\ \text{N})(2.00\ \text{m})(1-\cos 30.0°) = \boxed{107\ \text{J}}.$$

A person with a remote mountain cabin plans to install her own hydroelectric plant. A nearby stream is 3.00 m wide and 0.500 m deep. Water flows at 1.20 m/s over the brink of a waterfall 5.00 m high. The manufacturer promises only 25.0% efficiency in converting the potential energy of the water–Earth system into electric energy. Find the power she can generate. (Large-scale hydroelectric plants, with a much larger drop, are more efficient.)

The volume flow rate is the volume of water going over the falls each second:

$$3\text{ m}(0.5\text{ m})(1.2\text{ m/s}) = 1.8\text{ m}^3/\text{s}$$

The mass flow rate is $\frac{m}{t} = \rho\frac{V}{t} = (1\,000\text{ kg/m}^3)(1.8\text{ m}^3/\text{s}) = 1\,800\text{ kg/s}$

If the stream has uniform width and depth, the speed of the water below the falls is the same as the speed above the falls. Then no kinetic energy, but only gravitational energy is available for conversion into internal and electric energy.

The input power is $\mathscr{P}_{\text{in}} = \frac{\text{energy}}{t} = \frac{mgy}{t} = \frac{m}{t}gy = (1\,800\text{ kg/s})(9.8\text{ m/s}^2)(5\text{ m}) = 8.82\times10^4\text{ J/s}$

The output power is $\mathscr{P}_{\text{useful}} = (\text{efficiency})\mathscr{P}_{\text{in}} = 0.25(8.82\times10^4\text{ W}) = \boxed{2.20\times10^4\text{ W}}$