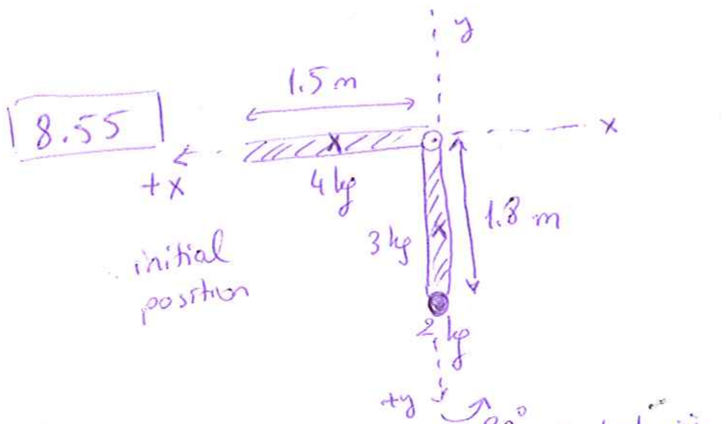
Ch8. problems: 55, 86, 95, 110, 111

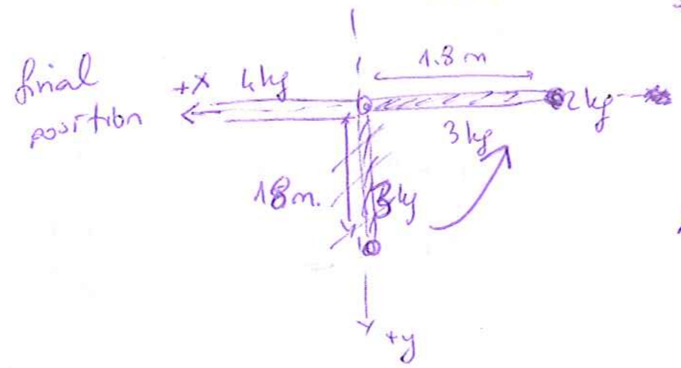
8.55



$$x_{cm} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3 + \dots}{m_1 + m_2 + m_3 + \dots}$$

$$y_{cm} = \frac{m_1 y_1 + m_2 y_2 + \dots}{m_1 + m_2 + \dots}$$

* each uniform bar can be represented by a point mass at its geometrical center.



$$x_i = \frac{m_1 x_1 + m_2 \overset{=0}{x_2} + m_3 \overset{=0}{x_3}}{m_1 + m_2 + m_3} = \frac{(4\,kg)(0{,}750\,m) + 0 + 0}{4\,kg + 3\,kg + 2\,kg}$$

$$x_i = 0{,}333\ m.$$

$y_f = 0$

$$x_f = \frac{(4\,kg)(0{,}75\,m) + (3\,kg)(-0{,}9\,m) + (2\,kg)(-1{,}8\,m)}{9\,kg}$$

$= -0{,}366\ m.$

$$y_i = \frac{m_1 \overset{=0}{y_1} + m_2 y_2 + m_3 y_3}{m_1 + m_2 + m_3} = \frac{0 + (3\,kg)(0{,}9\,m) + (2\,kg)(1{,}8)}{(4+3+2)\,kg}$$

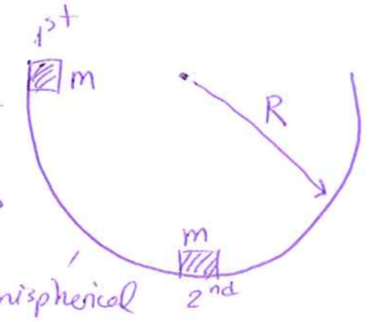
$y_i = 0{,}7\ m.$

the change in cm. → $x_f - x_i = -0{,}700\ m.$

$y_f - y_i = -0{,}700\,m$

c.m. moves 0,700 m to the right and 0,700 m upward.

8.86



2 identical masses

hemispherical bowl

They stick together when they collide, how high above the bottom of bowl will they go after colliding?

Let 1^{st} mass speed v just before striking the 2^{nd} mass.

Before collision

energy cons.

$$\frac{1}{2} m v^2 = m g R$$

$$v = \sqrt{2 g R}$$

$$v = v_1$$

Collision

momentum cons.

let v_2 after collision

$$m v_1 = 2 m v_2$$

$$v_2 = \frac{v_1}{2} = \sqrt{\frac{gR}{2}}$$

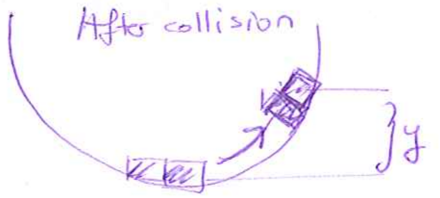
After collision

energy conservation

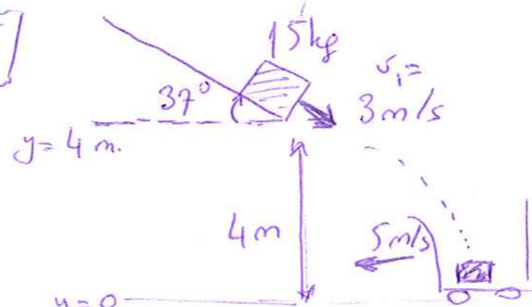
$$\frac{1}{2}(2m) v_2^2 = (2m) g y$$

$$y = \frac{v_2^2}{2g} = \frac{1}{2g}\left(\frac{gR}{2}\right)$$

$$y = R/4$$



8.95



Package lands in the cart, they roll off together.

a) speed of package just before it lands in the cart.

b) final speed of the cart.

Before collision

energy conservation

$$K_1 + U_1 = K_2 + U_2$$

$$\frac{1}{2} m v_1^2 + m g y_1 = \frac{1}{2} m v_2^2$$

$$v_2 = \sqrt{v_1^2 + 2 g y_1} = 9{,}35\,m/s$$

Collision

momentum conservation in horizontal direction (not in vertical due vertical force exerted by the floor on the cart)

P_x = const.

A: package

B: cart

$$m_A \underbrace{v_{A1x}}_{(3m/s)\cos 37°} + m_B \underbrace{v_{B1x}}_{-5m/s} = (m_A + m_B) v_{2x}$$

during free fall

$$\Rightarrow \boxed{v_{2x} = -3{,}29\,m/s}$$

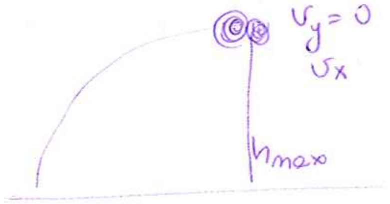
8.110

shell explodes into two; one 3 times heavier than the other.

Two fragments reach the ground at the same time.

If heavier one lands back at the same point from which shell is launched

- where the lighter one land?
- how much energy released in explosion?



heavier $m_A = 9$ kg

lighter $m_B = 3$ kg

$v_x = v_0 \cos 55°$

$= 86.0$ m/s

After collision $v_{Ax} = -86$ m/s

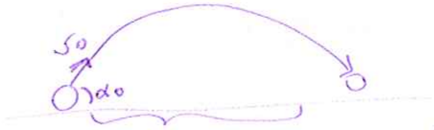
(fragment A returns launch point)

momentum conservation:

$$(12\text{ kg})(86\text{ m/s}) = (9\text{ kg})(-86\text{ m/s}) + (3\text{ kg})(v_{Bx})$$

$$v_{Bx} = 602 \text{ m/s}$$

If no explosion occurred.



horiz. range $= R = \frac{v_0^2}{g} \sin(2\alpha_0)$

$= 2157$ m.

Heavier fragments travels horizontal distance $= R/2 = 1078$ m.

$\Rightarrow$

$$\left(\frac{602\text{ m/s}}{86\text{ m/s}}\right)(1078\text{ m}) = 7546\text{ m}$$

from point of explosion

↳ $7546\text{ m} + 1078\text{ m} = 8624$ m from the launch point that the lighter fragment lands.

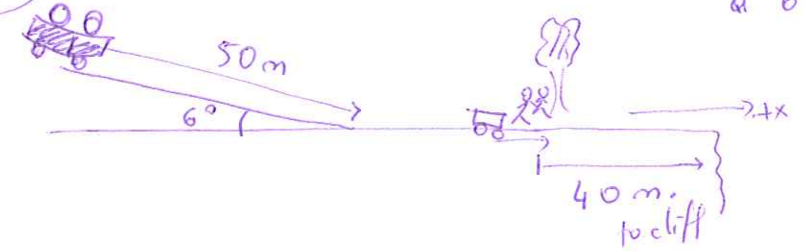
Energy released in explosion:

$$K_2 - K_1 = \frac{1}{2}(9\text{ kg})(86\text{ m/s})^2 + \frac{1}{2}(3\text{ kg})(602\text{ m/s})^2 - \frac{1}{2}(12\text{ kg})(86\text{ m/s})^2$$

$$= 5.33 \times 10^5 \text{ J}$$

8.111

Wagon with 2 boxes of gold at rest 50m up a 6° slope. Total mass = 300 kg.



Ranger m = 75 kg

Tonto m = 60 kg

they drop vertically into wagon.

a) If they require 5s. to grab the gold and jump out, will they make it before wagon goes over the edge?

b) When two heroes drop into wagon, is kinetic energy of the system (heroes + wagon) conserved? If not, does it increase or decrease?

wagon = A

2 people together = B

Let V : speed of combined object after collision

a) $U_1 + \cancel{K_1} = \cancel{U_2} + K_2$ (before collision)

$U_1 = K_2$

$m_A g (50m \cdot \sin 6°) = \frac{1}{2} m_A v_{A_1}^2$

$v_{A_1} = 10.12\, m/s$

For collision ; $P_{1x} = P_{2x}$

$m_A v_{A_1} = (m_A + m_B) V$

$V = \frac{(300\, kg)(10.12\, m/s)}{(300\, kg) + 75\, kg + 60\, kg}$

$= 6.98\, m/s$

After collision ;

In 5s., the wagon travels

$(5s)(6.98\, m/s) = 34.9\, m$

⇒ So, people will have time to jump out of wagon before it reaches the edge of the cliff.

b) wagon – $K_1 = \frac{1}{2}(300\, kg)(10.12\, m/s)^2 = 1.54 \times 10^4\, J$

neglect heroes kinetic energy just before the wagon compared to K_1.

$K_2 = \frac{1}{2}(435\, kg)(6.98\, m/s)^2 = 1.06 \times 10^4\, J.$

$K_1 - K_2 = 4.8 \times 10^3\, J.$ * Kinetic energy of the system decreases