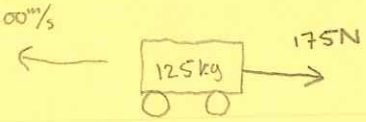
Impulse and Momentum

(2016)

① 

$$\sum \vec{J} = \Delta \vec{p}$$

$$\sum \vec{F} t = m \Delta \vec{v}$$

$$\frac{\sum \vec{F} t}{m} = \Delta \vec{v} = \vec{v} - \vec{v}_0$$

$$\vec{v} = \frac{\sum \vec{F} t}{m} + \vec{v}_0 = \frac{175\,N(1.50\,s)}{125\,kg} + (-8.00\,m/s)$$

$$\vec{v} = -5.90\,m/s$$

$\vec{v} = 5.90\ m/s$ west

② 

a. $\sum \vec{p}_0 = \sum \vec{p}$

$m_1 \vec{v}_{1i} + M_2 \vec{v}_{2i} = (m_1 + M_2)\vec{v}$

$1200\,kg\,(14\,m/s) + 5600\,kg(-22\,m/s) = (1200\,kg + 5600\,kg)\vec{v}$

$\vec{v} = -15.64705882\ m/s$

$\vec{v} = 16\ m/s$ south

b. Impulse IS change in momentum!

$$\Delta \vec{p}_c = \vec{p}_c - \vec{p}_{0c} = 1200\,kg(-15.647\ldots\,m/s) - 1200\,kg(14\,m/s) = -35\,576.4709\ kgm/s$$

36 000 Ns south

c. $\Delta \vec{p}_T = \vec{p}_T - \vec{p}_0 = 5600\,kg(-15.647\ldots\,m/s) - 5600\,kg(-22\,m/s) = 35\,576.4709\ kgm/s$

36 000 Ns north

d. EQUAL MAGNITUDES, OPPOSITE DIRECTIONS!

③ a. $\vec{J} = \vec{F} t = 175\,N(3.50\,s) = 612.5\,Ns \simeq$ 613 Ns East

b. $\Delta \vec{p} = \vec{J} = 612.5\,Ns =$ 613 kgm/s East

c. $\Delta \vec{p} = m \Delta \vec{v}$

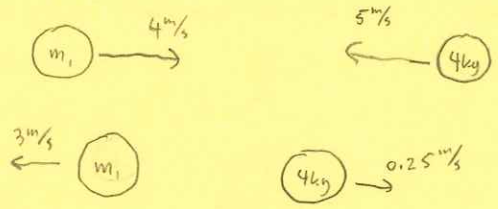
$$\Delta \vec{v} = \frac{\Delta \vec{p}}{m} = 2.72\overline{7}\ m/s =$$ 2.72 m/s East

d. $\vec{a} = \frac{\Delta \vec{v}}{t} = \frac{2.72\overline{7}\ m/s}{3.50\,s} = 0.7\overline{7}\ m/s^2 \simeq$ 0.778 m/s² East OR $\vec{a} = \frac{\sum \vec{F}}{m} = \frac{175\,N}{225\,kg} = 0.7\overline{7}\ m/s^2$

e. $\Delta \vec{v} = \vec{v} - \vec{v}_0 \Rightarrow \vec{v} = \vec{v}_0 + \Delta \vec{v} = -4.00\,m/s + 2.72\overline{7}\ m/s = -1.27\overline{7}\ m/s \simeq$ 1.28 m/s West

(4) a. EQUAL TO
b. EQUAL TO
c. GREATER THAN
d. EQUAL TO
e. GREATER THAN

(5)



$$\Sigma \vec{p}_0 = \Sigma \vec{p}$$

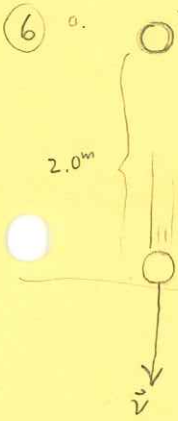
$$m_1(4\,m/s) + 4kg(-5\,m/s) = m_1(-3\,m/s) + 4kg(0.25\,m/s)$$

$$4m_1 - 20 = -3m_1 + 1$$

$$7m_1 = 21$$

$$m_1 = 3kg$$

(6) a.



$\vec{v}_0 = 0$
$\vec{a} = -9.80\,m/s^2$
$\vec{d} = -2.0\,m$
$\vec{v} = ?$
$\vec{v}^2 = \vec{v}_0^2 + 2\vec{a}\vec{d}$
$\vec{v} = \pm\sqrt{2(-9.8)(-2)}$
$\vec{v} = -6.260990337$

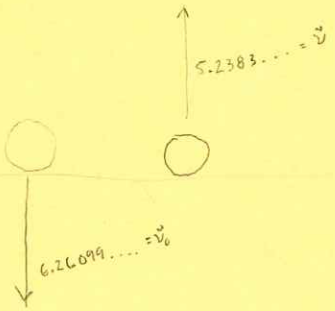
$\vec{v} = 6.3\,m/s$ down

b.

$\vec{v} = 0$
$\vec{a} = -9.80\,m/s^2$
$\vec{d} = 1.4\,m$
$\vec{v}_0 = ?$
$\vec{v}^2 = \vec{v}_0^2 + 2\vec{a}\vec{d}$
$-\vec{v}_0^2 = 2\vec{a}\vec{d}$
$\vec{v}_0 = \pm\sqrt{-2\vec{a}\vec{d}}$
$\vec{v}_0 = +\sqrt{-2(-9.8)(1.4)}$
$= 5.238320341\,m/s$

$\vec{v}_0 = 5.2\,m/s$ up

c.



$\Delta\vec{v} = \vec{v} - \vec{v}_0$
$\Delta\vec{v} = 5.238...\,m/s - (-6.260...)\,m/s$
$\Delta\vec{v} = 11.49931068\,m/s$ UP

$\Delta\vec{v} = 11\,m/s$ UP

d. $\Delta\vec{p} = m\Delta\vec{v} = 0.065kg(11.499.....) = 0.747455194\,kg\,m/s$ = $0.75\,kg\,m/s$ UP

e. 0.75 Ns UP

f. $\Sigma \vec{J} = \Sigma \vec{F} t$

$\Sigma \vec{F} = \frac{\Sigma \vec{J}}{t} =$ **7.5 N up**

g.

$\Sigma \vec{F} = 7.4745\ldots$ N ↑

$F_N - F_g = 7.4745\ldots$ N

$F_N = 7.474\ldots + F_g$

$F_N = 8.1$ N up

---

⑦ $\Sigma \vec{F} t = m\vec{v} - m\vec{v}_0$

$175\text{N}(10.50\text{s}) = 125\text{kg}\,\vec{v} - 125\text{kg}(-8.00\text{m/s})$

$\vec{v} = 6.70$ m/s east

⑧ $\Sigma \vec{F} t = m\vec{v} - m\vec{v}_0$

$0.35\text{N}(60.0\text{s}) = 2.0\text{kg}\,\vec{v} - 2.0\text{kg}(1.7\text{m/s})$

$\vec{v} = 12$ m/s east

⑨ $\Sigma \vec{F} t = m\vec{v} - m\vec{v}_0$

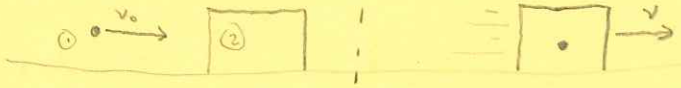
$25\text{N}(3.0\text{s}) = 12\text{kg}(-5.0\text{m/s}) - 12\text{kg}\,\vec{v}_0$

$\vec{v}_0 = -11.25$ m/s

$\vec{v}_0 = 11$ m/s west

10 a. North b. ? c. ? d. North e. ? f. North g. North h. ?

11 a.



$\Sigma \vec{p}_0 = \Sigma \vec{p}$

$m_1\vec{v}_{01} + m_2\vec{v}_{02} = (m_1 + m_2)\vec{v}$

$\vec{v} = 8.5365\ldots$

$v = 8.5$ m/s

b.

$\Sigma \vec{p}_0 = \Sigma \vec{p}$

$m_1\vec{v}_{01} + m_2\vec{v}_{02} = m_1\vec{v}_1 + m_2\vec{v}_2$

$0.125\text{kg}(350\text{m/s}) = 0.125(150\text{m/s}) + 5.0\text{kg}\,\vec{v}_2$

$\vec{v}_2 = 5.0$ m/s

$\Sigma \vec{p}_0 = \Sigma \vec{p}$

$m_1\vec{v}_{01} + m_2\vec{v}_{02} = m_1\vec{v}_1 + m_2\vec{v}_2$

$0.150\text{kg}(350\text{m/s}) = 0.150\text{kg}(-150\text{m/s}) + 5.0\text{kg}\,\vec{v}_2$

$\vec{v}_2 = 12.5$ m/s

$v_2 = 13$ m/s

12. In both cases the speed of the egg when it lands and when it stops is the same, as is mass of the egg.

So with pillow or without $\Delta\vec{p} = \vec{J}$ is the same.

What is different is TIME! The pillow increases time

so $\vec{F} = \frac{\vec{J}}{t}$ decreases!

C.

---

(13) 2D: Separate into $\hat{x}$ and $\hat{y}$:

$\hat{x}$: $\Sigma \vec{p}_{ox} = \Sigma \vec{p}_x$

$m_1\vec{v}_{1ox} + m_2\vec{v}_{2ox} = m_1\vec{v}_{1x} + m_2\vec{v}_{2x}$

$1.0\text{kg}(2.40\text{m/s}) = 1.0\text{kg}(1.70\cos 30^\circ) + 0.80\,\vec{v}_{2x}$

$\vec{v}_{2x} = 1.159696017\ \text{m/s}$

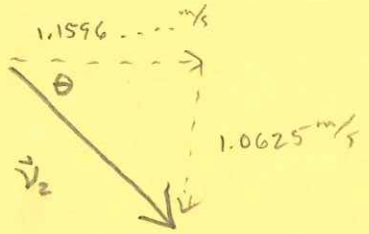
$\vec{v}_0$ is horizontal, ∴ is ALL $\hat{x}$!

$\hat{y}$: $\Sigma \vec{p}_{oy} = \Sigma \vec{p}_y$

$m_1\vec{v}_{1oy} + m_2\vec{v}_{2oy} = m_1\vec{v}_{1y} + m_2\vec{v}_{2y}$

$0 = 1.0\text{kg}(1.70\sin 30^\circ) + 0.80\vec{v}_{2y}$

$\vec{v}_{2y} = -1.0625\ \text{m/s}$



$\vec{v}_2 = 1.57\ \text{m/s}\ [42.5^\circ \text{ below } +x]$