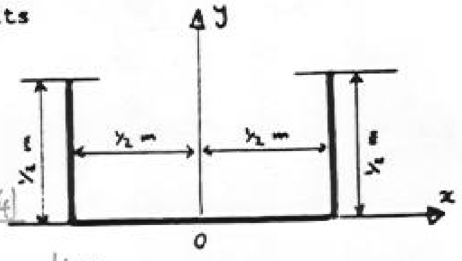
Problems from chapter 9

A uniform wire of mass M and length 2 m is bent as to be all in one plane (see figure). Find its center of mass with respect to point O.



A. (0, 1/8) m
B. (-1, 1/8) m
C. (1/2, 1/3) m
D. (1/8, 3/8) m
E. (1/3, 1/3) m

c.m is along the y-axis.
$x_{cm} = 0$
$y_{cm} = \frac{(\frac{1}{4}m)(\frac{M}{4}) + (\frac{1}{4}m)(\frac{M}{4})}{M} = (\frac{3}{4}m)(M/4)/M = \frac{1}{8}m$

A 3.00 kg particle has a velocity V1 = 10.0*t**2 * j m/s. A 2.00 kg particle is moving with a velocity V2 = 4.0*t * i m/s, where t is in seconds. Find the acceleration of the center of mass of the system of these two particles at t = 0.500 sec. (i and j are unit vectors along the x and y axis, respectively)

$\vec{a}_{cm} = \frac{d\vec{v}_{cm}}{dt}$ | $\vec{v}_{cm} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1+m_2}$

A. 1.70 m/s**2 at 62 deg to x-axis
B. 5.34 m/s**2 at 45 deg to x-axis
C. 6.21 m/s**2 at 75 deg to x-axis
D. 3.20 m/s**2 at 51 deg to x-axis
E. 8.69 m/s**2 at 83 deg to x-axis

$\vec{a}_{cm} = \frac{8}{5}\hat{i} + 12t\hat{j}$ m/s² ⟵ $\vec{v}_{cm} = \frac{30t^2\hat{j} + 8t\hat{i}}{5}$ m/s

$|\vec{a}_{cm}| = 6.21$ m/s² $\theta = \tan^{-1}\left(\frac{6}{1.6}\right) = 75°$

Two masses, 5 kg each, have velocities (in m/s)

$\vec{V}_1 = 12*\vec{i} - 16*\vec{j}$, $\vec{V}_2 = -20*\vec{i} + 14*\vec{j}$.

Determine the momentum of the center of mass of the two masses (in kg*m/s).

A. $160*\vec{i} - 150*\vec{j}$
B. $-40*\vec{i} + 10*\vec{j}$
C. $40*\vec{i} - 10*\vec{j}$
D. $-40*\vec{i} - 10*\vec{j}$
E. $-160*\vec{i} + 150*\vec{j}$

$\vec{P} = M\vec{v}_{cm} = (m_1 + m_2)\vec{v}_{cm} = m_1\vec{v}_1 + m_2\vec{v}_2 = -40\hat{i} - 10\hat{j}$

A bomb initially at rest explodes into three equal fragments. The velocities of two of the fragments are respectively 3*i m/s and - 6*j m/s. Find the velocity of the third fragment (i and j are unit vectors in the x and y directions, respectively).

A. 0 m/s
B. (-i + 2*j) m/s
C. (-i + 2*j) m/s
D. (3*i - 6*j) m/s
E. (-3*i + 6*j) m/s

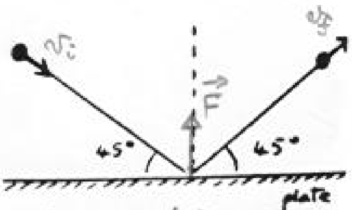
$\vec{P}_i = \vec{P}_f$ over view

x-axis: $0 = 3m + v_x m \Rightarrow v_x = -3$ m/s before

y-axis: $0 = -6m + v_y m \Rightarrow v_y = 6$ m/s

$\vec{v}_3 = ?$, $3\hat{i}$ m/s $= \vec{v}_1$, $-6\hat{j}$ m/s $= \vec{v}_2$

A 2.00 kg object with a speed of 50.0 m/s strikes a steel plate at an angle of 45 deg and rebounds at the same speed and angle as shown in the figure. Find the change of the linear momentum (magnitude and direction) of the object.



A. 100 kg.m/s parallel to the plate
B. 141 kg.m/s at 45 deg to the plate
C. 100 kg.m/s at 45 deg to the plate
(D). 141 kg.m/s perpendicular to the plate
E. zero

$\Delta p_x = m v_{fx} - m v_{ix} = m(v_{fx} - v_{ix}) = 0$

$\Delta \vec{p} = 0\hat{i} + 141\hat{j}$ ⟸ $\Delta p_y = m(v_{fy} - v_{iy}) = 2mv\cos 45° = 141$ kg m/s

A projectile is fired from a gun at an angle of 60 deg with the horizontal and with an initial speed of 200 m/s. At the highest point of its flight the projectile explodes into three pieces of equal mass. The velocity of the first and second pieces immediately after the explosion are V1 = 60*i + 30*j m/s and V2 = 30*i - 90*j m/s. Find the velocity of the third piece immediately after the explosion. (i and j are unit vectors directed horizontally and vertically, respectively.)

A. 210*i + 60*j m/s
B. 90*i - 60*j m/s
C. - 90*i + 60*j m/s
D. 210*i - 60*j m/s
E. 10*i - 60*j m/s

$v_y = 0$, v_x — before — after; v_0, 60°

$\Delta p_x = 0 \Rightarrow P_{xi} = P_{xf}$

$100M = 60\frac{M}{3} + 30\frac{M}{3} + v_x\frac{M}{3}$

$\Rightarrow v_x = 210$ m/s

A bomb, initially at rest, explodes by itself into three equal fragments. The velocities of two fragments are:

$(3\vec{i} + 2\vec{j})$ m/s and $(-\vec{i} - 3\vec{j})$ m/s.

Find the velocity of the third fragment.

(A.) $(-2\vec{i} + \vec{j})$ m/s

B. zero

C. $(-4\vec{i} - 5\vec{j})$ m/s

D. $(2\vec{i} - 3\vec{j})$ m/s

E. $(4\vec{i} + 5\vec{j})$ m/s

m, $v = 0$, before; m/3, v_1; m/3, v_2

$\Delta p_x = 0 \Rightarrow 0 = 3\frac{M}{3} - \frac{M}{3} + v_x\frac{M}{3}$ $\quad v_x = -2$ m/s

$\Delta p_y = 0 = 2\frac{M}{3} - \frac{3M}{3} + v_y\frac{M}{3} \Rightarrow v_y = 1$ m/s

$\vec{v} = (-2\hat{i} + \hat{j})$ m/s