(A) What is the total linear momentum $\vec{p}_{total}$ of the system?

Sol'n:
System: The two small objects
Surroundings: Nothing significant. (In outer space)
Assumptions: Assuming $|v| << c$
Definition: $\vec{p} = m\vec{v}$ and $\vec{p}_{total} = \sum_i \vec{p_i} \rightarrow \vec{p}_{total} = m\vec{v}_1 + m\vec{v}_2 =< mv_1 + mv_2, 0, 0 >$

(B) What is the velocity of the center of mass, $\vec{v}_{CM}$?

Sol'n:
System, surroundings and assumptions: See previous part.
Definition: $\vec{v}_{CM} = \frac{\vec{p}_{CM}}{M_{total}}$
We know that $\vec{p}_{CM} = \vec{p}_{total}$
Thus: $\vec{v}_{CM} = \frac{m\vec{v}_1 + m\vec{v}_2}{2m} = \frac{\vec{v}_1 + \vec{v}_2}{2} =< \frac{\cancel{m}v_1 + \cancel{m}v_2}{2}, 0, 0 >$

(C)What is the total angular momentum $\vec{L}_{total,C}$ of the system relative to point C?

Sol'n:
System, surroundings and assumptions: See previous part.
Definition: $\vec{L}_A = \vec{r}_A \times \vec{p}$ and $\vec{L}_{total} = \sum_i \vec{L}_i$
Thus: $\vec{L}_{total,C} =< -d, h+L, 0 > \times < mv_1, 0, 0 > + < -d, h, 0 > \times < mv_2, 0, 0 >$
So, $\vec{L}_{total,C} =< 0, 0, -mv_1(h+L) - mv_2 h >$

(D)What is the translational angular momentum $\vec{L}_{trans,C}$ of the system relative to point C?

Sol'n:
System, surroundings and assumptions: See previous part.
Definition:$\vec{L}_{Trans} = \vec{r}_{CM} \times \vec{p}_{total}$
Thus: $\vec{L}_{trans,C} =< -d, h + L/2, 0 > \times < mv_1 + mv_2, 0, 0 >=< 0, 0, -(mv_1 + mv_2)(h + L/2) >$

(E) What is the rotational angular momentum $\vec{L}_{rot}$ of the system?

Sol'n:
System, surroundings and assumptions: See previous part.
Definition: $\vec{L}_{Tot} = \vec{L}_{rot} + \vec{L}_{trans}$
Thus: $\vec{L}_{rot} = \vec{L}_{tot} - \vec{L}_{trans} =< 0, 0, -mv_1(h+L) - mv_2 h > - < 0, 0, -(mv_1 + mv_2)(h + L/2) >$
Which is:$\vec{L}_{rot} =< 0, 0, -mv_1(\cancel{h+} L/2) - mv_2(\cancel{h} - L/2) > = < 0, 0, -\frac{mv_1 L}{2} + \frac{mv_2 L}{2} >$

After a short amount of time Δt,

(F)What is the total (linear) momentum $\vec{p}_{total}$ of the system?

Sol'n:
System: Same as above
Surroundings: Whatever is exerting the forces on the masses
Assumptions: $|v| << c$
Momentum Principle: $\Delta\vec{p} = \vec{F}_{net}\Delta t$
Thus: $\vec{p}_{system,f} = \vec{p}_{system,i} + \vec{F}_{net}\Delta t$
Giving us:$\vec{p}_{system,f} =< mv_1 + F_1\Delta t + mv_2 - F_2\Delta t, 0, 0 >$

(G)What is the total angular momentum $\vec{L}_{total,C}$ of the system?

Sol'n:
System, surroundings and assumptions: see previous part.
Angular Momentum Principle: $\Delta\vec{L} = \vec{\tau}_{net}\Delta t$ where $\vec{\tau} = \vec{r} \times \vec{F}$
For this system:
$\vec{\tau}_{net} =< -d, h + L, 0 > \times < F_1, 0, 0 > + < -d, h, 0 > \times < -F_2, 0, 0 >$
$\vec{\tau}_{net} =< 0, 0, -F_1(h + L) + F_2h >$
Since $\vec{L}_{total,f} = \vec{L}_{total,i} + \vec{\tau}_{net}\Delta t$
$\vec{L}_{total,f} =< 0, 0, -mv_1(h + L) - mv_2h > + < 0, 0, -F_1(h + L)\Delta t + F_2h\Delta t >$
$\vec{L}_{total,f} =< 0, 0, -(mv_1 + F_1\Delta t)(h + L) - (mv_2 - F_2\Delta t)h >$

Or: compute new momenta & plug into definition of $\vec{L}$