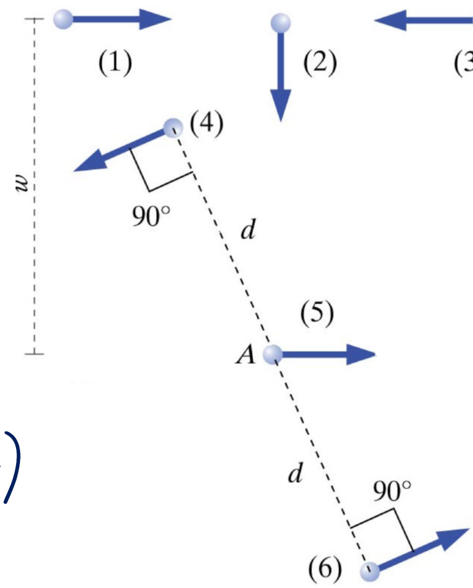
Physics 2211 GPS Week 13

Problem #1

In the diagram below, six identical particles of mass m and speed v are moving relative to a point A, the current location of particle (5). The distance of these particles from point A is indicated in the diagram. As usual, x is to the right, y is up and z is out of the page, towards you.



(a) Calculate the angular momentum of particle 1 with respect to A (particle 1 moves in the positive x-direction).

$$\vec{L}_{1A} = \vec{r}_{1A} \times \vec{p}_1 = wmv\,(-\hat{z})$$

(b) Calculate the angular momentum of particle 2 with respect to A (particle 2 moves in the negative y-direction).

$\vec{L}_{2A} = \vec{r}_{2A} \times \vec{p}_2 = 0$ because $\vec{r}_{2A}$ and p_2 are antiparallel.

(c) Calculate the angular momentum of particle 3 with respect to A (particle 3 moves in the negative x-direction)..

$$\vec{L}_{3A} = \vec{r}_{3A} \times \vec{p}_3 = wmv\,(+\hat{z})$$

(d) Calculate the angular momentum of particle 4 with respect to A.

$$\vec{L}_{4A} = \vec{r}_{4A} \times \vec{p}_4 = dmv\,(+\hat{z})$$

(e) Calculate the angular momentum of particle 5 with respect to A.

$\vec{L}_{5A} = \vec{r}_{5A} \times \vec{p}_5 = 0$ because $\vec{r}_{5A} = 0$.

(f) Calculate the angular momentum of particle 6 with respect to A.

$$\vec{L}_{6A} = \vec{r}_{6A} \times \vec{p}_6 = dmv\,(+\hat{z})$$

(g) Calculate the total angular momentum of the system of particles with respect to A.

$$\vec{L}_A = \sum_i \vec{L}_{iA} = (wmv - wmv + dmv + dmv)\,\hat{z} = 2dmv\,(\hat{z})$$

Problem #2

Approximate the total angular momentum of the solar system.

Answers will vary. Watch for the following in students' solutions:

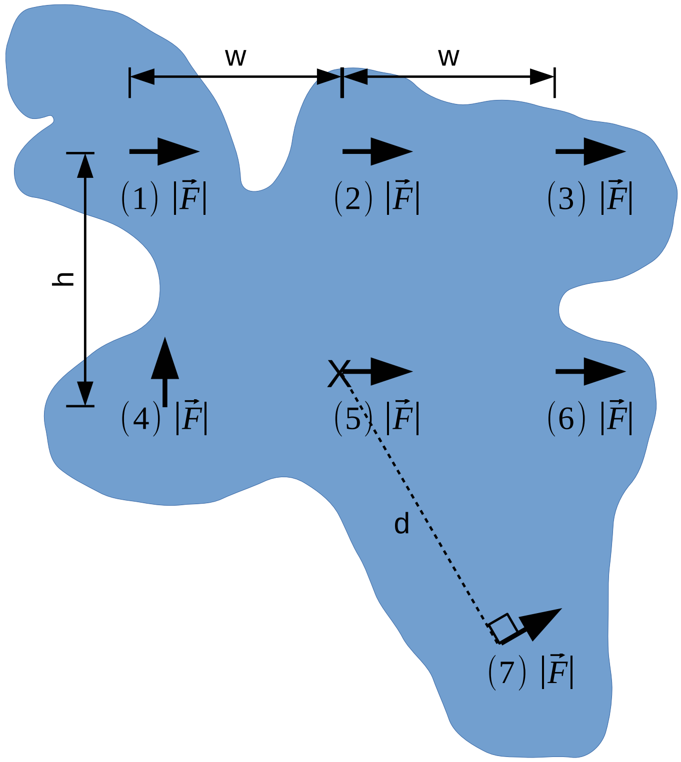
1. Did they specify a location about which to find L? The center of the Sun is a natural choice.

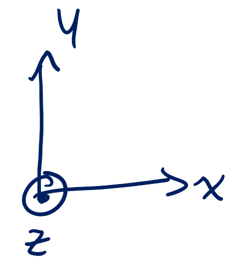
2. Do they account for L_{rot} and L_{trans}?

It might be helpful to remind students that the rotational axis of rotation for most planets is perpendicular to the orbital plane.

Problem #3

As shown in the figure below, seven forces all with magnitude $|\vec{F}|$ are applied to an irregularly shaped object. Each force is applied at a different location on the object, indicated by the tail of the arrow; the directions of the forces differ. The forces are separated by distance w, h, and d as indicated in the figure. For the following questions, circle the value of the torque for the corresponding force relative to location "X" (x to the right, y up, z out of the page).





$\vec{\tau} = \vec{r} \times \vec{F}$

A. The torque from force (1):

$wF\hat{z}$	$hF\hat{z}$	$dF\hat{z}$	$(w+h)F\hat{z}$	$(w^2+h^2)F\hat{z}$	$(w^2+h^2)^{(1/2)}F\hat{z}$	$d^2F\hat{z}$	0
$-wF\hat{z}$	$-hF\hat{z}$	$-dF\hat{z}$	$-(w+h)F\hat{z}$	$-(w^2+h^2)F\hat{z}$	$-(w^2+h^2)^{(1/2)}F\hat{z}$	$-d^2F\hat{z}$	none of these

B. The torque from force (2):

$wF\hat{z}$	$hF\hat{z}$	$dF\hat{z}$	$(w+h)F\hat{z}$	$(w^2+h^2)F\hat{z}$	$(w^2+h^2)^{(1/2)}F\hat{z}$	$d^2F\hat{z}$	0
$-wF\hat{z}$	$-hF\hat{z}$	$-dF\hat{z}$	$-(w+h)F\hat{z}$	$-(w^2+h^2)F\hat{z}$	$-(w^2+h^2)^{(1/2)}F\hat{z}$	$-d^2F\hat{z}$	none of these

C. The torque from force (3):

$wF\hat{z}$	$hF\hat{z}$	$dF\hat{z}$	$(w+h)F\hat{z}$	$(w^2+h^2)F\hat{z}$	$(w^2+h^2)^{(1/2)}F\hat{z}$	$d^2F\hat{z}$	0
$-wF\hat{z}$	$-hF\hat{z}$	$-dF\hat{z}$	$-(w+h)F\hat{z}$	$-(w^2+h^2)F\hat{z}$	$-(w^2+h^2)^{(1/2)}F\hat{z}$	$-d^2F\hat{z}$	none of these

D. The torque from force (4):

$wF\hat{z}$	$hF\hat{z}$	$dF\hat{z}$	$(w+h)F\hat{z}$	$(w^2+h^2)F\hat{z}$	$(w^2+h^2)^{(1/2)}F\hat{z}$	$d^2F\hat{z}$	0
$-wF\hat{z}$	$-hF\hat{z}$	$-dF\hat{z}$	$-(w+h)F\hat{z}$	$-(w^2+h^2)F\hat{z}$	$-(w^2+h^2)^{(1/2)}F\hat{z}$	$-d^2F\hat{z}$	none of these

E. The torque from force (5):

$wF\hat{z}$	$hF\hat{z}$	$dF\hat{z}$	$(w+h)F\hat{z}$	$(w^2+h^2)F\hat{z}$	$(w^2+h^2)^{(1/2)}F\hat{z}$	$d^2F\hat{z}$	0
$-wF\hat{z}$	$-hF\hat{z}$	$-dF\hat{z}$	$-(w+h)F\hat{z}$	$-(w^2+h^2)F\hat{z}$	$-(w^2+h^2)^{(1/2)}F\hat{z}$	$-d^2F\hat{z}$	none of these

F. The torque from force (6):

$wF\hat{z}$	$hF\hat{z}$	$dF\hat{z}$	$(w+h)F\hat{z}$	$(w^2+h^2)F\hat{z}$	$(w^2+h^2)^{(1/2)}F\hat{z}$	$d^2F\hat{z}$	0
$-wF\hat{z}$	$-hF\hat{z}$	$-dF\hat{z}$	$-(w+h)F\hat{z}$	$-(w^2+h^2)F\hat{z}$	$-(w^2+h^2)^{(1/2)}F\hat{z}$	$-d^2F\hat{z}$	none of these

G. The torque from force (7):

$wF\hat{z}$	$hF\hat{z}$	$dF\hat{z}$	$(w+h)F\hat{z}$	$(w^2+h^2)F\hat{z}$	$(w^2+h^2)^{(1/2)}F\hat{z}$	$d^2F\hat{z}$	0
$-wF\hat{z}$	$-hF\hat{z}$	$-dF\hat{z}$	$-(w+h)F\hat{z}$	$-(w^2+h^2)F\hat{z}$	$-(w^2+h^2)^{(1/2)}F\hat{z}$	$-d^2F\hat{z}$	none of these

H. At time $t = 0$ the angular momentum of the object, relative to relative to location "X", is zero. Determine the total angular momentum of the object, relative to "X", a short time Δt later.

$$\vec{L}_f = \cancel{\vec{L}_i}^{\,0} + \vec{\tau}_{net}\Delta t$$

$$\vec{\tau}_{net} = (-hF\hat{z} - hF\hat{z} - hF\hat{z} - wF\hat{z} + dF\hat{z})$$

$$= F(-3h - w + d)\hat{z}.$$

$$\Rightarrow \boxed{\vec{L}_f = F(-3h - w + d)\Delta t\,\hat{z}}$$