PHYS 101: General Physics 1 — KOÇ UNIVERSITY — Fall Semester 2013

College of Sciences

Section 5 — Quiz 11 — 20 December 2013

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: Student ID: Signature:

The position vector of a particle of mass 2.0 kg is given as a function of time by *r = (6.0i+5.0t j)* (here, time *t* is given in seconds). Determine the angular momentum of the particle as a function of time.

Section 5

$m = 2\,kg$

$\vec{r} = 6\hat{i} + 5t\,\hat{j}$ (m)

$\vec{L} = ?$

$\vec{v} = \frac{d\vec{r}}{dt} = 5\,\hat{j}$ m/s

$\vec{L} = \vec{r} \times \vec{p}$

$= \vec{r} \times m\vec{v}$

$= (6\hat{i} + 5t\,\hat{j}) \times (2\,kg)(5\,\hat{j}\ m/s)$

$\vec{L} = 60\,(kg\,m^2/s)\ \hat{k}$

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Section 2 | Quiz 11 | 20 December 2013

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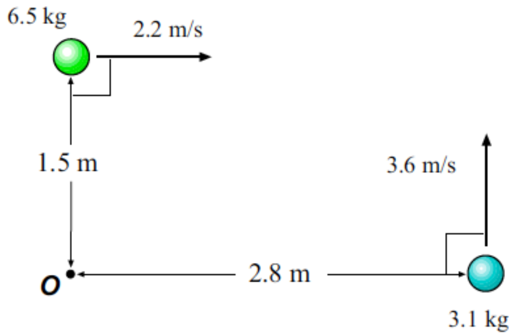
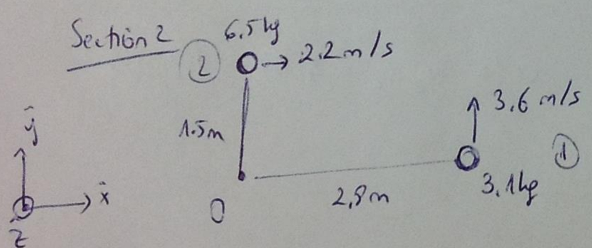
Quiz duration: 10 minutes
Name: Student ID: Signature:

Two objects are moving as shown in the figure. What is their total angular momentum about point O?

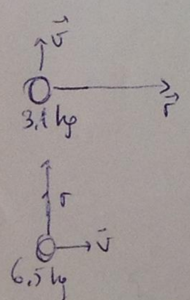




$\vec{L}_{total} = ?$ $\vec{L}_{tot} = \vec{L}_1 + \vec{L}_2$

$L_1 = r_1 m_1 v_1$
$= (2,8m)(3,1kg)(3.6m/s)$

$L_2 = r_2 m_2 v_2$
$= (1,5m)(6,5kg)(2.2m/s)$



$\vec{L} = \vec{r} \times \vec{p}$
$= \vec{r} \times m\vec{v}$

$\vec{L}_1$ in $\hat{z}$

$\vec{L}_2$ in $-\hat{z}$

$\vec{L}_{total} = \vec{L}_1 + \vec{L}_2$
$= 31,248\,\hat{z} - 21,45\,\hat{z}$
$= 9,8\,(kgm^2/s)\,\hat{z}$

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Section 3 | Quiz 11 | 20 December 2013

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Quiz duration: 10 minutes

Name: Student ID: Signature:

Suppose that the Sun runs out of nuclear fuel and suddenly collapses to form a white dwarf star, with a diameter equal to that of the Earth. Assuming no mass loss, what would then be the Sun's new rotation period, which currently is about 25 days? Assume that the Sun and the white dwarf are uniform, solid spheres; and the present radius of the Sun is approximately 100 times the radius of Earth. Hint: moment of inertia of a uniform solid sphere with mass *M* and radius *R* is $2MR^2/5$.

Section 3

$R_{sun} = 100\, R_E$ $\quad T = 25$ day

$R'_{sun} = R_E$ $\quad T' = ?$

$I_1 \omega_1 = I_2 \omega_2$ $\quad \left(\omega = 2\pi f = \frac{2\pi}{T}\right)$

$\downarrow$

$\left(I_{\text{solid sphere}} = \frac{2}{5} M R^2\right)$

$$\frac{2}{5} M\, 100^2 R_E^2 \frac{2\pi}{(25\text{ day})} = \frac{2}{5} M R_E^2 \frac{2\pi}{T'}$$

$$T' = \frac{25\text{ day}}{10000} = \frac{1}{400}\text{ day} \cdot \frac{24\text{ h}}{1\text{ day}} \cdot \frac{60\text{ min}}{1\text{ h}}$$

$$T' = \underline{3.6\text{ min}}$$

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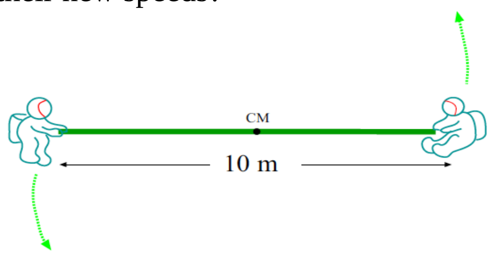
Section 4 | Quiz 11 | 20 December 2013

Closed book. No calculators are to be used for this quiz.

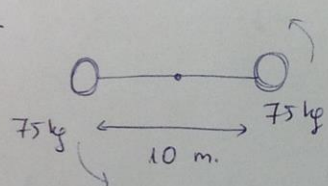
Quiz duration: 10 minutes

Name: Student ID: Signature:

Two astronauts each having a mass of 75 kg are connected by a 10m rope of negligible mass. They are isolated in space, orbiting their center of mass at speeds of 5.0 m/s . If, by pulling on the rope, the astronauts shorten the distance between them to 5.0m, what are their new speeds?



Section 4



$v = 5\,m/s$. The distance shortened to 5m.

$v' = ?$

$L_1 = L_2$

$I_1 w_1 = I_2 w_2$

$w_1 = \frac{v_1}{r_1} = \frac{5\,m/s}{5\,m} = 1$

$I_1 = m r_1^2 = 2 \cdot 75 \cdot (5m)^2$

$I_2 = m r_2^2 = 2 \cdot 75\ (2{,}5m)^2$

$w_2 = \frac{I_1}{I_2} w_1$

$= \frac{2 \cdot 75 \cdot 25}{2 \cdot 75 (2{,}5)^2} = 4$

$v' = w_2 \cdot r_2 = 4 \cdot 2{,}5 = \underline{10\,m/s}$

PHYS 101: General Physics 1	KOÇ UNIVERSITY College of Sciences	Fall Semester 2013
Section 1	Quiz 11	20 December 2013

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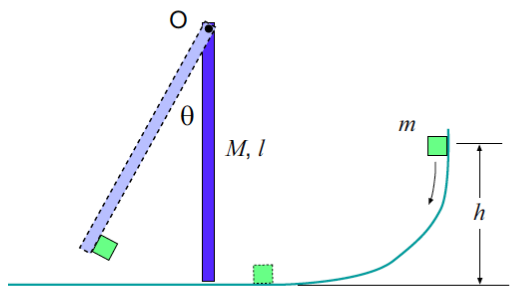
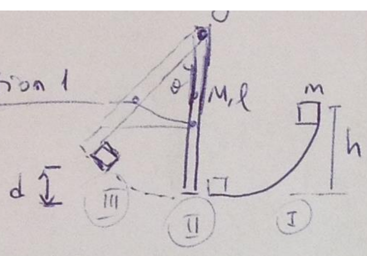
Quiz duration: 10 minutes

Name: Student ID: Signature:

The particle of mass m shown in the figure slides down the frictionless surface and collides with the uniform vertical rod, sticking to it. The rod pivots about O through the angle theta before momentarily coming to rest. Find θ in terms of the other parameters given in the figure.



Section 1



I $\quad K_1 + U_1 = K_2 + U_2$

$v = \sqrt{2gh} \qquad (v = \omega r)$

$\omega = \dfrac{\sqrt{2gh}}{l}$

II $\quad L_1 = L_2$ since the external torque is zero, angular momentum is conserved.

$I_1 \omega_1 = I_2 \omega_2$

$m l^2 \dfrac{\sqrt{2gh}}{l} = \left(\frac{1}{3} m l^2 + m l^2\right) \omega_2$ =(moment of inertia of the rod + moment of inertia of the particle)x w_2

$\omega_2 = \dfrac{m l \sqrt{2gh}}{\frac{4}{3} m l^2} = \dfrac{3}{4} \dfrac{\sqrt{2gh}}{l}$

III $\quad K_1 + U_1 = K_2 + U_2$ you can denote as K_2,U_2 and K_3 , U_3

$\frac{1}{2}\left(\frac{4}{3} m l^2\right) \omega_2^2 + M \frac{l}{2} g = mgd + Mgd/2$

$\frac{1}{2}\left(\frac{4}{3} m l^2\right) \frac{9}{16} \frac{2gh}{l^2} + M \frac{l}{2} g = d \dfrac{(2mg + Mg)}{2}$

$\dfrac{\frac{3}{2} mgh + Mgl}{2mg + Mg} = d$

$d = \dfrac{3mh + 2Ml}{4m + 2M}$

$d = l(1 - \cos\theta)$

$\cos\theta = 1 - d/l \rightarrow \boxed{\theta = \cos^{-1}(1 - d/l)}$