PHYS 101: General Physics 1 KOÇ UNIVERSITY Fall Semester 2011

College of Sciences

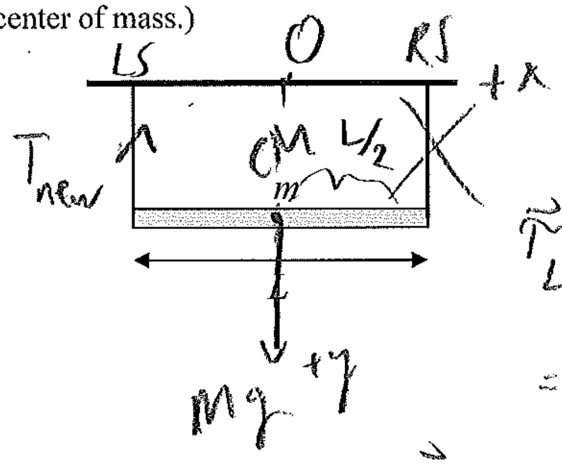
Section 1 Quiz 10 8 December 2011

Closed book. No calculators are to be used for this quiz.
Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

A uniform rod of mass m, length L is suspended by two equal strings as shown in the figure. Calculate the tension in the left string and the linear acceleration of the rod's center of mass at the instant the right string is cut.
($I_{cm\text{-}rod} = mL^2/12$, where I_{cm} is the moment of inertia of an object about an axis passing through it's center of mass.)

$\otimes$ z - in page



$t = 0^+$

$$\vec{F}_{net} = (Mg - T_{new})\hat{j} = Ma_y\hat{j} = Ma_{cm}\hat{j}$$

$$\boxed{T_{new} = M(g - a_{CM}) = M(g - \alpha L/2)}$$

$$\vec{r}_{LS} = -L/2\,\hat{i}$$

$$\vec{\tau}_{LS} = \vec{r}_{LS} \times \vec{F}_{LS} = \left(-\frac{L}{2}\hat{i}\right) \times \left(-T_{new}\hat{j}\right)$$

$$\vec{\tau}_{LS} = \vec{\tau}_{Net} = \left(\frac{L}{2}T_{new}\right)\hat{k}$$

$$\tau_{Net} = I_{CM}\alpha \rightarrow \left(\frac{L}{2}T_{new}\right) = \left(\frac{ML^2}{12}\right)\alpha$$

$$\rightarrow \left[\frac{L}{2}M\left(g - \alpha\frac{L}{2}\right)\right] = \frac{ML^2}{12}\alpha \rightarrow \boxed{\alpha = \frac{3g}{2L}}$$

$$\boxed{a_{cm} = \alpha\frac{L}{2} = \frac{3g}{4}}$$

$$\boxed{T_{new} = \frac{Mg}{4}}$$

(Alternative Solution)

PHYS 101: General Physics 1 KOÇ UNIVERSITY Fall Semester 2011

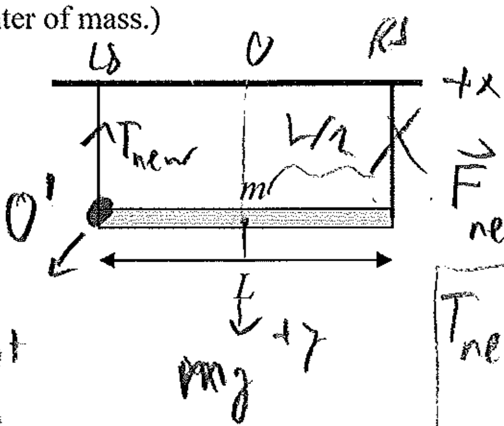
College of Sciences

Section 1 Quiz 10 8 December 2011

Closed book. No calculators are to be used for this quiz.
Quiz duration: 15 minutes

Name: Student ID: Signature:

A uniform rod of mass m, length L is suspended by two equal strings as shown in the figure. Calculate the tension in the left string and the linear acceleration of the rod's center of mass at the instant the right string is cut.
($I_{\text{cm-rod}} = mL^2/12$, where I_{cm} is the moment of inertia of an object about an axis passing through it's center of mass.)



⊗ z - in page

Parallel axis thm:

$$I_{O'} = I_{CM} + M\left(\frac{L}{2}\right)^2$$

$$\boxed{I_{O'} = \frac{ML^2}{3}}$$

$$\vec{F}_{net} = (Mg - T_{new})\hat{j} = Ma_{cM}\hat{j}$$

$$\boxed{\begin{aligned} T_{new} &= M(g - a_{cm}) \\ &= M(g - \alpha L/2) \end{aligned}}$$

$\vec{W} = Mg\hat{j} \Rightarrow$ causes torque about O'

$$\vec{\tau}_{O'} = (L/2\,\hat{i}) \times (Mg\hat{j}) = \frac{MgL}{2}\hat{k} = I_{O'}\underbrace{\alpha\hat{k}}_{\vec{\alpha}}$$

$$\to \frac{MgL}{2} = \left(\frac{ML^2}{3}\right)\alpha \to \boxed{\alpha = 3g/2L}$$

$$\boxed{a_{cM} = \alpha\frac{L}{2} = 3g/4}$$

$$\boxed{T_{new} = Mg/4}$$

PHYS 101: General Physics 1 **KOÇ UNIVERSITY** **Fall Semester 2011**

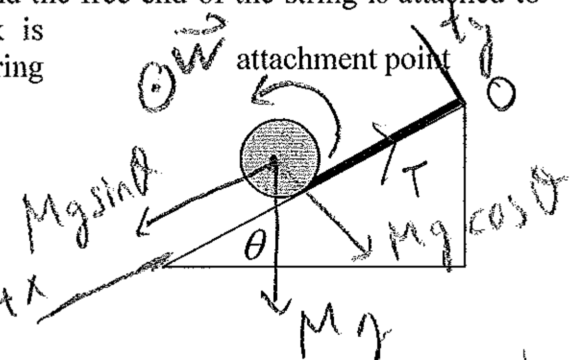
College of Sciences

Section 2 **Quiz 10** **8 December 2011**

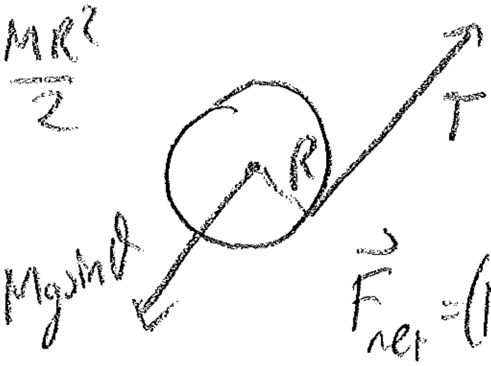
Closed book. No calculators are to be used for this quiz.
Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

A long <u>massless</u> string is wrapped around the rim of a solid disk of mass m, radius R. The disk is placed on an inclined surface and the free end of the string is attached to the top of the inclined surface. The disk is released from rest. Find the tension in the string as it unwraps.



$I_{solid\ disk} = \frac{MR^2}{2}$



$\vec{F}_{net} = (Mg\sin\theta - T)\hat{i} = Ma_{cm}\hat{i}$

$T = M(g\sin\theta - \alpha R)$

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

$= (-R\hat{j}) \times (-T\hat{i})$

$= (-RT)\hat{k}$

$\vec{\tau}$ $\odot$ out of page

right-hand rule

$\vec{\tau} = (-RT)\hat{k} = I_{disk}(-\alpha\hat{k})$

$\to TR = \left(\frac{MR^2}{2}\right)\alpha$

$\to M(g\sin\theta - \alpha R) = \frac{MR^2}{2}\alpha$

$\boxed{\alpha = \frac{2g\sin\theta}{3R}} \to a_{cm} = \frac{2g\sin\theta}{3}$

$T = M\left(g\sin\theta - \frac{2g\sin\theta}{3}\right) = \frac{Mg\sin\theta}{3}$

PHYS 101: General Physics 1 KOÇ UNIVERSITY Fall Semester 2011

College of Sciences

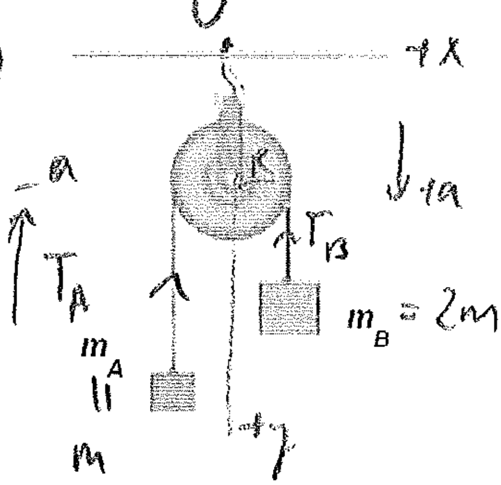
Section 3 Quiz 10 8 December 2011

Closed book. No calculators are to be used for this quiz.
Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

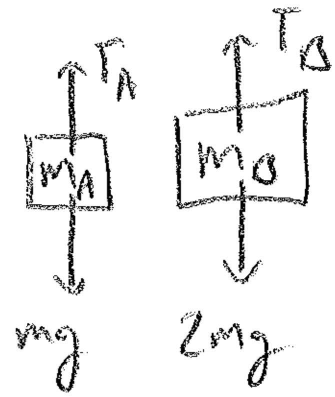
The Atwood machine shown in the figure has $m_A = m$, $m_B = 2m$, and the pulley is a disk of mass m, radius R. The pulley is suspended by a hook from the ceiling. The rope moves without slipping on the surface of the pulley. Find the force the ceiling exerts on the hook.

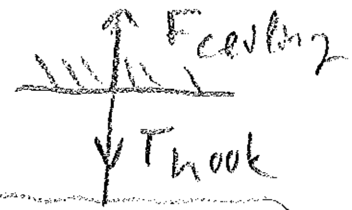
$\boxed{\tau_{net} \neq 0 \longleftrightarrow T_a \neq T_b}$



$I = \frac{mR^2}{2}$

$\downarrow +a$ $\otimes z$ - in page

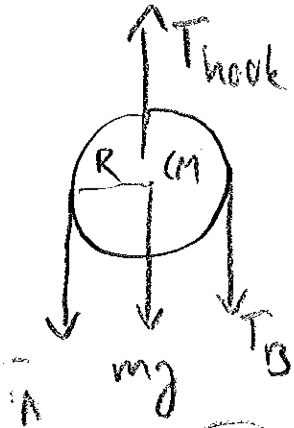




$\boxed{F_{ceiling} = T_{hook}}$

$\vec{F}_A = (mg - T_A)\hat{j} = m(-a\hat{j})$ | $\vec{F}_B = (2mg - T_B)\hat{j} = 2m(+a\hat{j})$

$\boxed{T_A = m(g + \alpha R)}$ $\boxed{T_B = 2m(g - \alpha R)}$



: $\vec{F}_{pulley} = (mg + T_A + T_B - T_{hook})\hat{j} = m\vec{a}_{pulley} = 0$

$\boxed{T_{hook} = mg + T_A + T_B}$

$\tau_{net} = (T_B R - T_A R) = I\alpha \rightarrow (T_B - T_A) = \frac{mR}{2}\alpha$

$\rightarrow \boxed{\alpha = 2g/7R} \rightarrow \boxed{T_A = \frac{9mg}{7}}; \boxed{T_B = \frac{10mg}{7}} \rightarrow \boxed{F_{ceiling} = \frac{26mg}{7}}$

PHYS 101: General Physics 1 KOÇ UNIVERSITY Fall Semester 2011

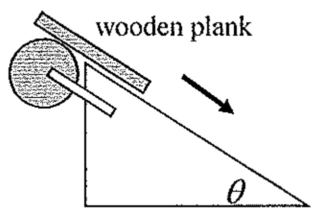
College of Sciences

Section 4 Quiz 10 8 December 2011

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

Name: Student ID: Signature:

A wooden plank of mass m is moving on a cylinder and being transferred on a frictionless inclined surface (the plank moves parallel to the inclined surface). The cylinder has mass m radius r, and it can rotate freely about the axis through its center. The plank is released from rest when all of its weight is supported at the contact point on the cylinder. Find the acceleration of the wooden plank, assuming that it moves without slipping on the cylinder initially. As the plank is being transferred on to the inclined surface, do you expect the acceleration remain constant? Explain briefly. ($I_{cm\text{-}disk} = mr^2/2$).



$mg\sin\theta - f_s = ma$ (1)

$\mu mg\cos\theta\, r = \frac{mr^2}{2}\alpha$, using no slip condition $\alpha = \frac{a}{r}$ we get $\mu mg\cos\theta = \frac{ma}{2}$. (2)
using (1) and (2) we get $a = \frac{2}{3}g\sin\theta$.

As the plank gets transferred to the inclined surface, the normal force it exerts on the cylinder will change. Therefore the acceleration will change. In general, the no slip condition may not hold during the entire motion.

PHYS 101: General Physics 1 **KOÇ UNIVERSITY** **Fall Semester 2011**

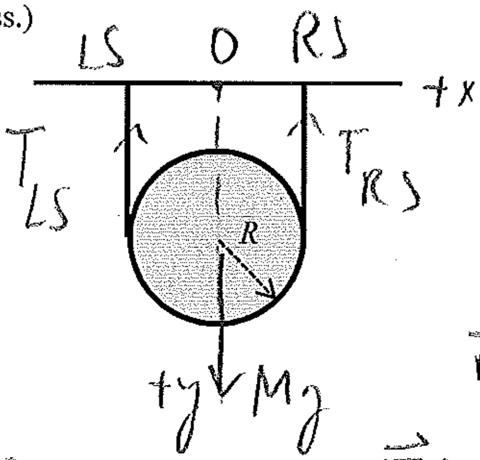
College of Sciences

Section 5 **Quiz 10** **8 December 2011**

Closed book. No calculators are to be used for this quiz.
Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

A uniform disk of mass M, radius R is suspended by two strings that are attached at the rim of the disk. Calculate the tension in the right string and the angular acceleration of the disk at the instant the left string is cut.
($I_{\text{cm-disk}} = mR^2/2$, where I_{cm} is the moment of inertia of an object about an axis passing through it's center of mass.)



⊗ z - in page

$t=0$

$\vec{F}_{net}(t=0) = (Mg - 2T)\hat{j} = 0$

$T(t=0) = \frac{Mg}{2}$

$\vec{r}_{LS} = -R\hat{i}$

$\vec{r}_{RS} = +R\hat{i}$

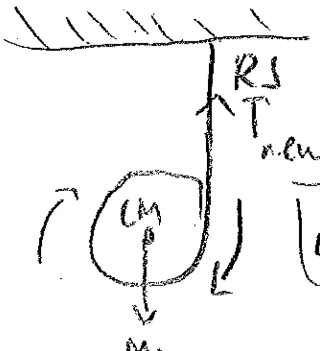
$\vec{F}_{RS}(t=0) = -T\hat{j} = -\frac{Mg}{2}\hat{j}$

$\vec{F}_{LS}(t=0) = -\frac{Mg}{2}\hat{j}$

$\vec{\tau}_{LS}(t=0) = \vec{r}_{LS} \times \vec{F}_{LS} = \frac{MgR}{2}\hat{k}$

$\vec{\tau}_{RS}(t=0) = -\frac{MgR}{2}\hat{k}$; $\boxed{\vec{\tau}_{net}(t=0) = 0}$

$t=0^+$



⊗ z

c.w. $\boxed{\vec{\alpha} = -\alpha\hat{k}}$

$\vec{F}_{net}(t=0^+) = (Mg - T_{new})\hat{j} = Ma_y(t=0^+)\hat{j}$

$Mg - T_{new} = Ma_y$

$\boxed{T_{new} = M(g - a_y) = M(g - \alpha R)}$

$\vec{\tau}_{RS}(t=0^+) = \vec{\tau}_{Net} = -T_{new}R\hat{k}$

$\to (-T_{new}R\hat{k}) = I_{cm}(-\alpha\hat{k})$

$M(g - \alpha R)R = \left(\frac{MR^2}{2}\right)\alpha$

$\boxed{\alpha(t=0^+) = 2g/3R}$

$\boxed{T_{new} = \frac{Mg}{3}}$