Physics 161, Homework 9

Due 12:00 pm, Friday, May 2; No Exceptions

Lubna Rana, Sections 0201-0206

Read Chapter 10, Sections 10.1-10.8 Make sure you do all the example problems in the chapter.

Short Answer Questions S1, S2, S3, S4; Problems P1 = S & B Ch 9, Problem 31; P2 = S & B Ch 10, Problem 3; P3, P4, P5, P6

Special Note: Please always:

1). PRINT your name and SECTION NUMBER CLEARLY on the front page of your HW. Failure to do so will now cost you points.

2). STAPLE all your pages. It is your responsibility to make sure that your hw gets submitted in one piece.

3). DO ALL THE PROBLEMS IN ORDER.

4). Show complete work and write logically consistent explanations for all questions and problems to receive credit.

5). Write units next to all dimensionful quantities.

Short Answer Questions:

S1). Three thin rods, each of length L are arranged in an inverted U, as shown. The two rods on the arms of the U each have mass M; the third rod has mass $3M$. Where is the center of mass of the assembly? A diagram is useful. (Note: Don't forget to draw your system. Also you need to specify both x_{cm} and y_{cm}.)

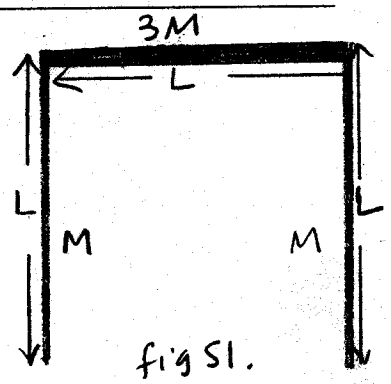


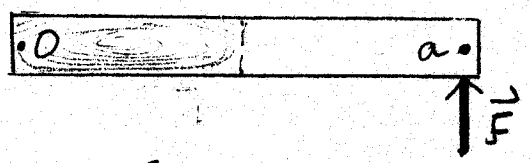
fig S1.

S2). A centrifuge is used to accustom astronaut trainees to high accelerations. The radius r of the circle traveled by the astronauts is $14m$.

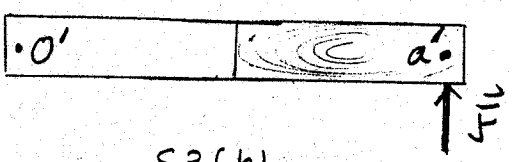
a). At what constant angular velocity ω must the centrifuge rotate if the astronaut is to be subject to a linear acceleration that is $11g$? ($11g$ means eleven times the acceleration due to gravity.)

b). What is the tangential acceleration of the astronaut if the centrifuge accelerates uniformly from rest to the angular velocity of part (a) in $120s$?

S3). The figure below shows a meter stick, half wood and half steel, that is pivoted at the wood end at O. A force **F** is applied to the steel end at a. In Fig S3b, the stick is reversed and pivoted at the steel end at O' and the same force is applied at the wood end at a'. Is the resulting angular acceleration of Fig S3a greater than, less than, or the same as that of Fig S3b.



S3(a)



S3(b)

S4). The figure below shows a rod free to turn about an axis through the point O. A force **F** having a magnitude of $28N$ is applied at an angle $\phi = 30°$ to the end of the rod at distance $r = 0.20m$ from the point O. Use the following alternative methods to find the numerical magnitude of the torque exerted by this force about the axis.

a). What is the component $F_{\perp r}$ of the force perpendicular to the rod? What then is the magnitude of the torque $\tau = r\,F_{\perp r}$?

b). What is the "lever/moment arm" $r_\perp$ of the force (i.e., the component of the position vector $\vec{r}$ from O to the point of application of the force? What then is the magnitude of the torque $\tau = F\,r_{\perp r}$?

c). What is the angle between the force $\vec{F}$ and the position vector $\vec{r}$? Use this information to calculate the torque using the cross product $\tau = \vec{r}\,\mathrm{x}\,\vec{F}$.

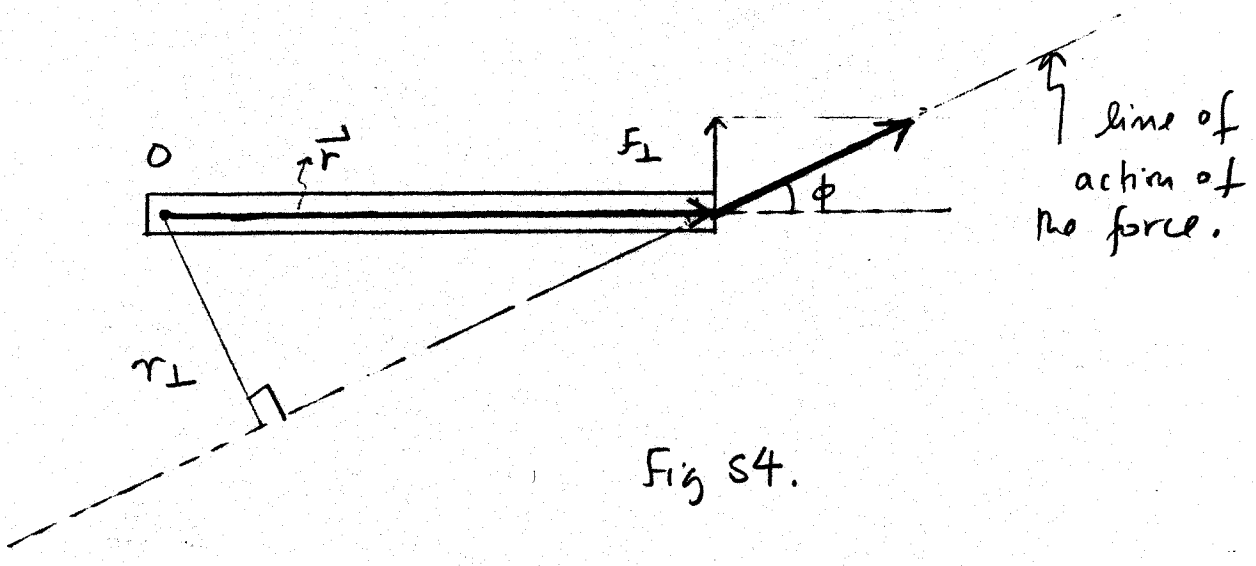


Fig S4.

Problems:

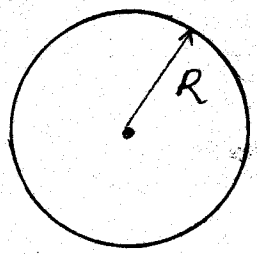
P1). *Serway & Beichner, Ch 9, Problem ~~21~~ 31*

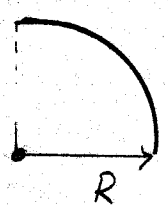
P2). *Serway & Beichner, Ch 10, Problem 3*

P3). A thin uniform rod of mass M is bent into a circle of radius R. (a). Using Equations 9.31 and 9.32 (*Serway & Beichner, CH 9, pg 271)*, show that the center of mass is located at the center of the circle.

b). Now suppose we chop off three quarters of the circular rod. Find x_{cm} and y_{cm} of the remaining quarter of a circle. Pick the center of the circle as the origin. *Hint: See Sample Problem SP1*

fig P3 (a)





(b)

P4). A block of mass M is attached to a thin string which is wrapped around a pulley free to rotate around a fixed horizontal axle. This pulley has a radius R and a moment of inertia I about its axle. All frictional forces are negligible. Use energy conservation to solve this problem.

a). What is the speed attained by the block after it is released from rest and has descended a vertical distance h?

b). What is this speed if the pulley is (i) a spoked wheel whose mass m is concentrated at the outer rim and (ii) if the pulley is a solid disk of mass m.

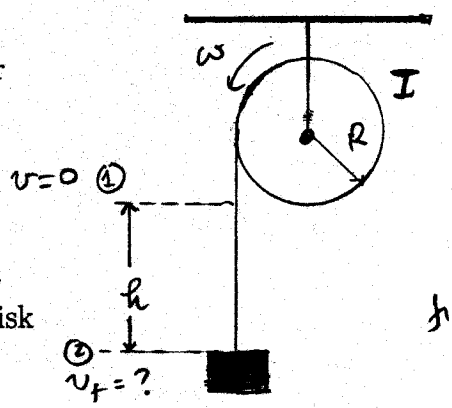


fig P4

c). Take your result from part (a) and explicitly check if you get the answer you would expect if the mass of the pulley is much much smaller than that of the block i.e., $m << M$.

P5). A meter stick is held vertically with one of its ends on the floor. When the meter stick is released, it topples. The end touching the floor does not slip. What is the speed with which the other end hits the floor?

P6): Some Key Points

a). The following questions relate to the equation:

$$v_{1i} - v_{2i} = -\left(v_{1f} - v_{2f}\right).$$

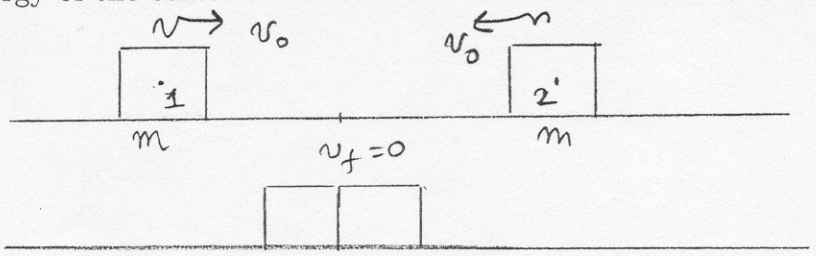
(i) Under what conditions is this equation valid?

(ii) Does this equation only apply when the masses of the two colliding objects are equal? If not then why doesn't mass appear at all in this equation whereas, the momentum conservation equation certainly contains the masses of the two objects

b). Show that for an object of mass m moving with velocity $\vec{v}$ the kinetic energy can be written as $K.E = p^2/2m$, where $\vec{p}$ is the momentum of the object.

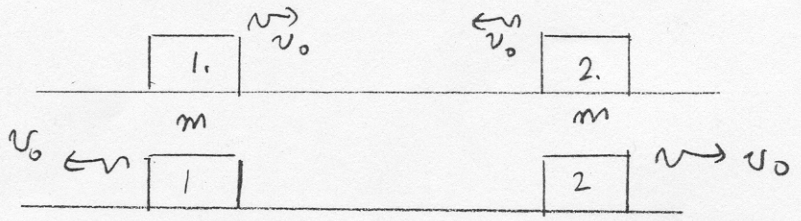
c). For the following collisions, calcualate the (i) the total kinetic energy and (ii) the kinetic energy of the center of mass **before and after the collision.**

1).



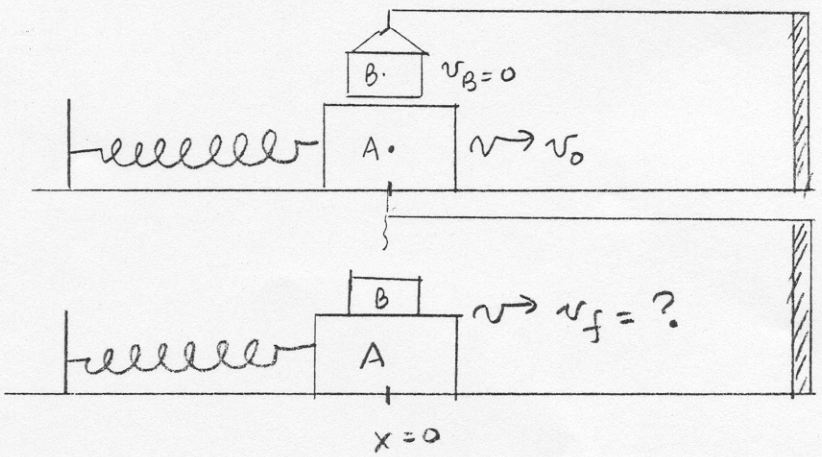
(1).

2).



(2).

3).



$m_A = M$

$m_B = m$