TOSHKENT SHAHRIDAGI INHA UNIVERSITETI
INHA UNIVERSITY IN TASHKENT

| | | | |
|---|---|---|---|
| STUDENT NAME: | X X X X | | |
| STUDENT ID NUMBER: | X X | DEPARTMENT: | X |

## FINAL EXAMINATION (Fall 2019)

| | | | |
|---|---|---|---|
| COURSE NAME: | ***PHYSICS 1*** | | |
| COURSE NUMBER: | **MSC1021** | | |
| EXAMINATION DATE: | | TIME: | |
| EXAMINATION DURATION: | **90 Minutes** | | |
| ADDITIONAL MATERIALS ALLOWED TO USE: | Own brain, own memory and logics. | | |
| SPECIAL INSTRUCTIONS: | **CALCULATORS ARE ALLOWED**<br>No Cheating and Good Luck! | | |

**Please do not open the examination paper until directed to do so.**

**READ INSTRUCTIONS FIRST:**

Desks should be free from all unnecessary items (books, notes, technology, food, water, clothes);

Use of any electronic device (Phone, iPod, iPad, laptop) is not allowed during the examination;

Cheating, talking to fellow students, singing, turning back are not allowed;

**Write your Name (*capital letters*), ID number and Department name in each page of your examination paper;**

Final answers must be written by only blue or black, non-erasable pen. Do not use highlighters or correction pen;

All answers should be written in the space provided for each question, unless specified the other way;

If additional space is required, you should notify Proctors;

If you have a problem please raise your hand and wait quietly for a Proctor;

You are not allowed to leave the examination room until you submit the examination papers.

STUDENT NAME:

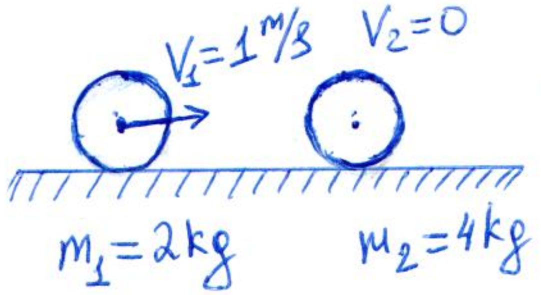
STUDENT ID NUMBER: DEPARTMENT:

Important: Please, write your solutions inside rectangular boxes. You have to write your final answer after the word «Answer», given in the last line of boxes. You can use back side of pages for your intermediate calculation *etc*. There are 8 problems (questions) in the paper.

(Total: 40 points, Obtained: ______)

1. As shown in the figure below, object $m_1$ collides stationary object $m_2$. *(a)*Find the magnitudes of velocities of the objects after collision (elastic collision). *(b)* What is the initial momentum and kinetic energy (before collision) of the objects? *(c)* What is the final momentum and kinetic energy (after collision) of the objects?

(Max: 7 Points, Obtained:_______)




According to the Law of Linear Momentum and conservation of Energy:

$\vec{P_i}=\vec{P_f}$ and $E_{tot_i}=E_{tot_f}$

$u_1$ and $u_2$ are final velocities of the balls

a) $\Rightarrow \begin{cases} m_1v_1+0=m_1u_1+m_2u_2 \\ \frac{m_1v_1^2}{2}+0=\frac{m_1u_1^2}{2}+\frac{m_2u_2^2}{2} \end{cases}$

$\begin{cases} m_1(v_1-u_1)=m_2u_2 \\ m_1(v_1^2-u_1^2)=m_2u_2^2 \end{cases} \Rightarrow v_1+u_1=u_2$

$\Rightarrow u_1=\frac{m_1-m_2}{m_1+m_2}v_1=\frac{2-4}{2+4}\cdot 1=\frac{-2}{6}=-\frac{1}{3}\approx-0,33\,m/s;$

$\Rightarrow u_2=\frac{2m_1v_1}{m_1+m_2}=\frac{2\cdot2\cdot1}{2+4}=\frac{4}{6}\approx0,66\,m/s;$

b) $E_{1i}=\frac{m_1v_1^2}{2}=1J$; $P_{1i}=m_1v_1=2\,kg\,m/s$; $E_{2i}=0$; $P_{2i}=0$ $(v_2=0)$

c) $E_{1f}=\frac{m_1u_1^2}{2}=\frac{2\cdot(-0,33)^2}{2}\approx0,1089J$; $P_{1f}=m_1u_1\approx-0,66\,kg\frac{m}{s}$

$E_{2f}=\frac{m_2u_2^2}{2}=0,8712J$; $P_{2f}=m_2u_2\approx2,64\,kg\frac{m}{s}$

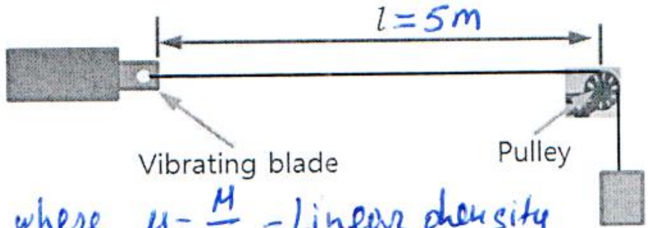
Answer:
a) $u_1=-\frac{1}{3}\,m/s$; $u_2=\frac{2}{3}\,m/s$; b) $E_{1i}=1J$; $P_{1i}=2\,kg\,m/s$; $E_{2i}=0$; $P_{2i}=0$
c) $E_{1f}=\frac{1}{9}J\approx0,1089J$; $P_{1f}=-\frac{2}{3}\,kg\,m/s$; $E_{2f}=\frac{8}{9}J$; $P_{2f}=\frac{8}{3}\,kg\frac{m}{s}$

STUDENT NAME: ×

STUDENT ID NUMBER: × DEPARTMENT: ×

2. A uniform string has a mass $M = 0.03\ kg$ and a length $L = 6\ m$. Tension is maintained in the string by suspending a block of mass $m = 2\ kg$ from one end (see figure below). (a) Find the speed $\boldsymbol{v}$ of a transverse wave pulse on this string. (b) Find the time **t** it takes the pulse to travel from the wall to the pulley. Neglect the mass of the hanging part of the string. (Use $g$=*10* $m/s^2$)

(Max: 3 Points, Obtained:_______)




Apply Newton's $2^{nd}$ Law to find Force $F_\tau$ in the string

$1m$ $F_\tau = mg$

Speed of the wave on a stretched string is found using $v = \sqrt{\frac{F_\tau}{\mu}}$

where $\mu = \frac{M}{L}$ - Linear density

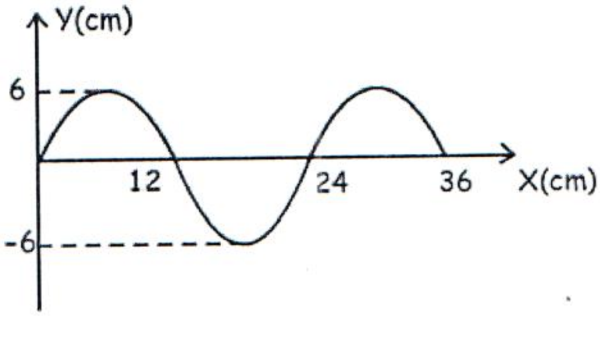
$$v = \sqrt{\frac{F_\tau}{\mu}} = \sqrt{\frac{mg}{M/L}} = \sqrt{\frac{2 \cdot 10}{0{,}03/6}} \simeq 63.25\ m/s$$

time: $t = \frac{d}{v} = \frac{l}{v} = \frac{5m}{63.25\ m/s} \simeq 0.079\ s \simeq 0{,}08\ s$

Answer: $v = 63{,}25\ m/s$ ; $t = 0{,}08\ s$

3. Picture given below shows wave motion of source having frequency 2 $s^{-1}$. Determine (a) its period($T$), (b) its angular frequency ($\omega$), (c) Find wavelength, *(d)* its amplitude ($x_m = A$), (e) velocity.

(Max: 3 Points, Obtained:_______)




$f = 2\ s^{-1} \Rightarrow$

a) $T = \frac{1}{f} = 0{,}5\ s$

b) $\omega = 2\pi f = 4\pi = 12{,}56\ \frac{rad}{s}$

Using graph $\Rightarrow$

c) $\lambda = 24\ cm$

d) $x_m = A = 6\ cm$

e) $v = \lambda f = 48\ cm/s$

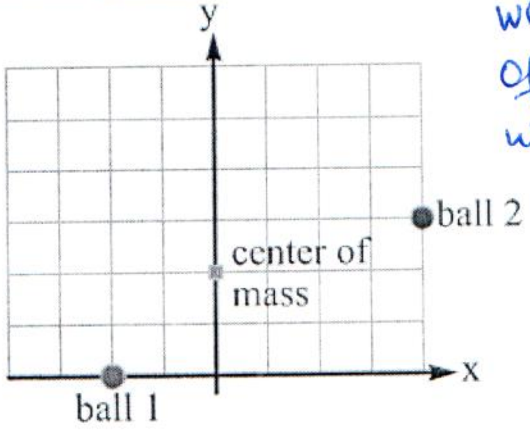
Answer: a) $T = 0{,}5\ s$; b) $\omega = 12{,}56\ rad/s$ ; c) $\lambda = 24\ cm$
d) $x_m = A = 6\ cm$ ; e) $v = 48\ cm/s = 0{,}48\ m/s$

STUDENT NAME:

STUDENT ID NUMBER: DEPARTMENT:

4. A system consists of three balls at different locations near the origin (see figure below). Ball 1 has a mass of 2.0 kg and is located on the $x$-axis at $x_1 = -2.0$ m; ball 2 has an unknown mass and is located at ($x_2 = +4.0$ m, $y_2 = +3.0$ m); ball 3 is somewhere on the $y$-axis at an unknown location, and it has a mass of 1.0 kg. The coordinates of the center-of-mass of this system are ($x_{CM} = 0$, $y_{CM} = +2.0$ m). The squares on the grid measure 1.0 m × 1.0 m. *(a)* Calculate the mass of ball 2. *(b)* Find the location of ball 3.

(Max: 5 Points, Obtained:________)




we can use the x-coordinate of the center-of-mass, because we know the x-coordinate of ball 3 is $x=0$.

$$x_{CM} = \frac{\sum m_i x_i}{\sum m_i} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3} = 0$$

$$\Rightarrow m_1 x_1 + m_2 x_2 + m_3 x_3 = 0 \Rightarrow m_2 = \frac{-m_1 x_1 - m_3 x_3}{x_2} = \frac{(-2)(-2)-0}{4} = 1\,kg$$

$$\Rightarrow m_2 = 1\,kg$$

Now we have to solve for the y-coordinate.

$$y_{CM} = \frac{\sum m_i y_i}{\sum m_i} = \frac{m_1 y_1 + m_2 y_2 + m_3 y_3}{m_1 + m_2 + m_3} \Rightarrow$$

$$y_3 = \frac{(m_1 + m_2 + m_3) y_{CM} - m_1 y_1 - m_2 y_2}{m_3} =$$

$$= \frac{4 \cdot 2 - 2 \cdot 0 - 1 \cdot 3}{1} = 5\,m$$

Answer: a) $m_2 = 1.0\,kg$ ; b) $x_3 = 0$ ; $y_3 = 5.0\,m$

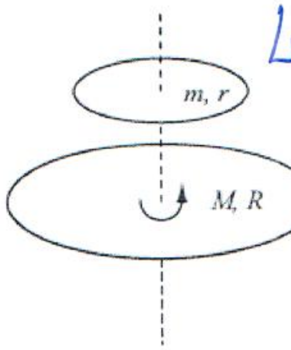
STUDENT NAME:

STUDENT ID NUMBER: DEPARTMENT:

5. A disk of radius *R=2 m* and mass *M=10 kg* is spinning at an angular velocity $\omega_0 = 32\, rad/s$. A non-rotating concentric disk of mass m=3 kg and radius r=1 m drops on it from a negligible height and the two rotate together (see figure below). Find the final angular velocity $\omega$ of system.

$\left(I_M = \frac{1}{2}MR^2 ;\ I_m = \frac{1}{2}mr^2\right)$

(Max: 6 Points, Obtained:________)




Let $I_M = \frac{1}{2}MR^2$ be the moment of Inertia of the disk of radius R, and $I_m = \frac{1}{2}mr^2$ the moment of Inertia of the other disk.

Initially the angular momentum of the system is $L_{M_i} = I_M \omega_0$, and when the two disks are rotating together the angular momentum is $L_f = (I_M + I_m)\omega$. Since angular momentum is conserved,

$L_i = L_f \Rightarrow$

$I_M \omega_0 = (I_M + I_m)\omega \Rightarrow$

$\omega = \frac{I_M \omega_0}{I_M + I_m} = \frac{\omega_0}{1 + \frac{mr^2}{MR^2}} = \frac{32}{1 + \frac{3 \cdot 1^2}{10 \cdot 2^2}} = \frac{32}{1{,}075} =$

$\simeq 29{,}77\ rad/s$

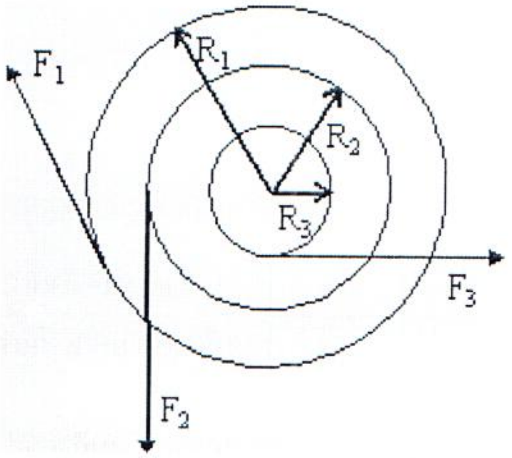
Answer: $\omega \simeq 29{,}77\ rad/s$

STUDENT NAME:

STUDENT ID NUMBER: DEPARTMENT:

6. The object in the diagram below is on a fixed frictionless axle. It has a moment of inertia of $I = 50\ kg \cdot m^2$. The forces acting on the object are $F_1 = 100\ N$, $F_2 = 200\ N$, and $F_3 = 250\ N$ acting at different radii $R_1 = 60\ cm$, $R_2 = 42\ cm$, and $R_3 = 28\ cm$. Find net torque (sum of all torques) and the angular acceleration of the object.

(Max: 7 Points, Obtained:________)




Since the axle is fixed we only need to consider the torques and use $\Sigma\tau = I\alpha$. Each of the forces is tangential to the object, R and F are at 90° to one another. Recall that clockwise torques are negative or into the paper in this case.

$$\Sigma\tau = I\alpha \qquad \vec{\tau}_{net} = \Sigma\vec{\tau} = \vec{\tau}_1 + \vec{\tau}_2 + \vec{\tau}_3$$

$$\tau_{net} = -R_1F_1 + R_2F_2 + R_3F_3 = -0{,}6 \cdot 100 + 0{,}42 \cdot 200 + 0{,}28 \cdot 250 = 94\,Nm$$

$$\alpha = \frac{-R_1F_1 + R_2F_2 + R_3F_3}{I} =$$

$$= \frac{-0{,}6 \cdot 100 + 0.42 \cdot 200 + 0{,}28 \cdot 250}{50} = 1{,}88\ rad/s^2$$

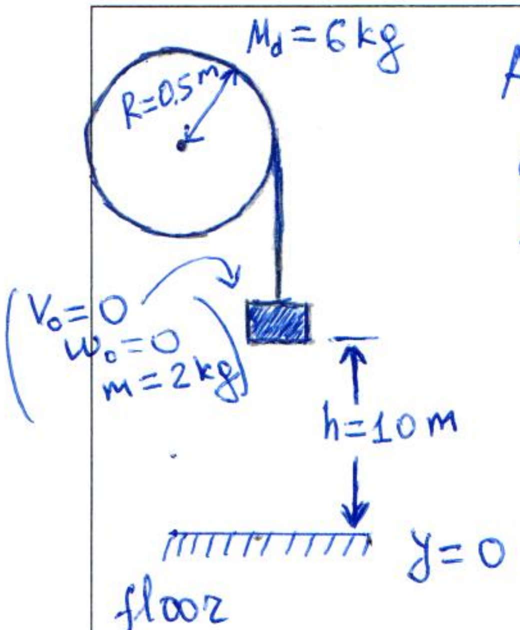
Answer: $\alpha = 1{,}88\ rad/s^2$ ; $\tau = 94\ N \cdot m$

STUDENT NAME: 

STUDENT ID NUMBER: DEPARTMENT: 

7. Find the (final) velocity of the *2-kg* mass just before it strikes the floor. Assume that the rotation of the disk is frictionless. The initial height $h$=*10 m*, the initial velocity of the block $\upsilon_0$=*0* and initial angular velocity of the disk $\omega_0$=*0*. ($I = \frac{1}{2}MR^2$)
($M_d = 6\,kg$ and $R = 0.5\,m$)

(Max: 5 Points, Obtained:_______)




According to Law of conservation of mechanical energy $mgh + U_{disk} = U_{disk} + \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

Using $I = \frac{1}{2}M_dR^2$ and $\omega = \frac{V}{R}$ we obtain

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{1}{2}M_dR^2\right)\left(\frac{V^2}{R^2}\right)$$

$$mgh = V^2\left(\frac{m}{2} + \frac{M_d}{4}\right) \Rightarrow$$

$$V = \sqrt{\frac{mgh}{\frac{m}{2} + \frac{M_d}{4}}} = \sqrt{\frac{2 \cdot 9.8 \cdot 10}{\frac{2}{2} + \frac{6}{4}}} \simeq 8.9\,m/s$$

Answer: $V \simeq 8,9\,m/s \simeq 9\,m/s$

STUDENT NAME: X

STUDENT ID NUMBER: X DEPARTMENT: X

8. The disk is rotating about its central axis like a merry-go-round. The angular position $\theta(t)$ of a reference line on the disk is given by $\theta(t) = -1 - 2t + 5t^2$, with $t$ in seconds and $\theta$ in radians. Determine the angular velocity function $\omega(t)$ and angular acceleration function $\alpha(t)$ for the reference line. Calculate the values of $\theta(t)$ (in rad), $\omega(t)$ (in rad/s), and $\alpha(t)$ (in rad/$s^2$) at $t = 5\,s$.

(Max: 4 Points, Obtained:_______)

$\theta(t) = -1 - 2t + 5t^2$ ;

$\omega(t) = \theta' = \frac{d\theta}{dt} = -2 + 10t$ ;

$\alpha(t) = \frac{d\omega}{dt} = 10\, rad/s^2$ ;

$\omega(t=5s) = -2 + 10 \cdot 5 = 48\, rad/s$ ;

$\theta(t=5s) = -1 - 2\cdot 5 + 5 \cdot 5^2 = 114\, rad$ ;

$\alpha(t=5s) = 10\, rad/s^2$ ;

Answer: $\omega(t) = -2 + 10t$ ; $\alpha(t) = 10$ ;
$\theta(t=5s) = 114\, rad$ ; $\omega(t=5s) = 48\, rad/s$
$\alpha(t=5s) = 10\, rad/s^2$