TOSHKENT SHAHRIDAGI INHA UNIVERSITETI
INHA UNIVERSITY IN TASHKENT

STUDENT NAME:	XXXXXX
STUDENT ID NUMBER:	UXXXXX
DEPARTMENT:	XXXXX

FINAL EXAMINATION

COURSE NAME:	PHYSICS 1
COURSE NUMBER:	MSC1021
EXAMINATION DATE:	16.12.2015
TIME:	
EXAMINATION DURATION:	120 Minutes
ADDITIONAL MATERIALS ALLOWED TO USE:	Own brain, own memory and logics.
SPECIAL INSTRUCTIONS:	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.

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Important: Please, write your solutions inside rectangular boxes, drawn below each question. Please, write your final answers after the word "Answer", given in the last line of boxes. You can use the backside of pages for your intermediate calculations *etc*. There are 11 problems (questions) in the paper.

(Total: 40 Marks, Obtained:_______)

[1] Two objects move on a horizontal frictionless surface along the same line in the same direction. The object 1 of mass 2.0 kg has a velocity of 15 *m/s* forward. The object 2 of mass 3.2 kg has a velocity of 11 *m/s* forward. The object 1 catches the object 2 and the two objects experience a completely inelastic collision. **What is the final (common) velocity of two objects after such inelastic collision?**

(Max: 3 Marks, Obtained:_______)

According to Law of conservation of Linear momentum:

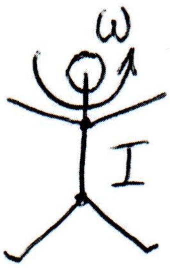
$P_i = P_f$ or $p_1 + p_2 = p'_{12}$ or $\boxed{m_1 \cdot V_1 + m_2 \cdot V_2 = (m_1 + m_2) \cdot V'}$

for completely inelastic collision

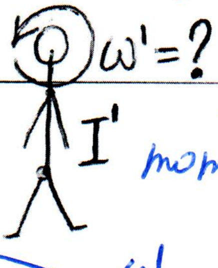
$$V' = \frac{m_1 \cdot V_1 + m_2 \cdot V_2}{m_1 + m_2} = \frac{2\,kg \cdot 15\,m/s + 3.2\,kg \cdot 11\,m/s}{2\,kg + 3.2\,kg} \simeq 12.54\,m/s$$

Answer: $V' \simeq 12.54\,m/s$ $(\simeq 13\,m/s)$ (forward).

[2] A skater is spinning at angular velocity *w* = 32.0 *rad/s* with her arms and legs extended outward. In this position, her moment of inertia with respect to the vertical axis, about which she is spinning, is *I* = 45.6 kg m^2. She pulls her arms and legs close to her body changing her moment of inertia to *I'* = 17.5 kg m^2. **Find her new angular velocity (*w'*=?).**



(Max: 3 Marks, Obtained:_______)



Due to Law of Conservation of Angular momentum $L = L'$ or $I\omega = I'\omega'$

$$\Rightarrow \omega' = \frac{I}{I'}\omega = \frac{45.6\,kg \cdot m^2}{17.5\,kg \cdot m^2} \cdot 32\,rad/s \simeq 83.4\,\frac{rad}{s}$$

Answer: $\omega' \simeq 83.4\,\frac{rad}{s}$

[3] A horizontal disk having a moment of inertia I_1 = 4.25 kg m^2, with respect to its axis of symmetry, is spinning counterclockwise about its axis of symmetry, as viewed from above, at 15.5 revolutions per

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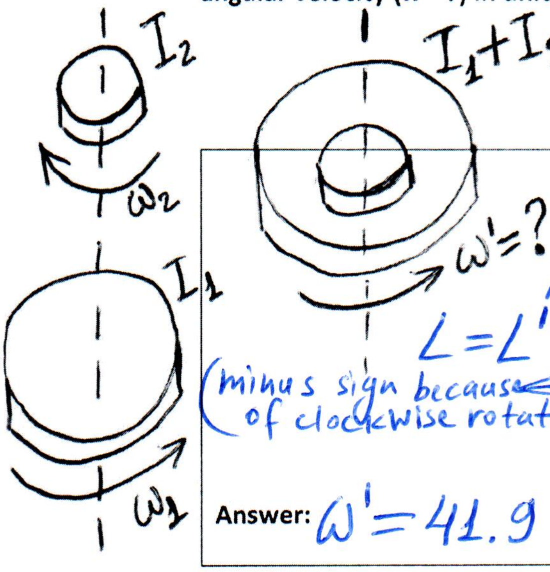
second on a frictionless massless bearing. A second disk having a moment of inertia $I_2 = 1.80$ kg m^2, with respect to its axis of symmetry, is spinning clockwise about the same axis (which is also its axis of symmetry) at 14.2 revolutions per second. A second disk drops on top of the first disk and the two disks stick together and rotate as one about their common axis of symmetry. **What is their new (common) angular velocity (w'=?) in units of radians per second?**

(Max: 4 Marks, Obtained:_______)



$$\omega_1 = 15.5\,\frac{rev}{s}\left(\frac{2\pi\, rad}{rev}\right) = 97.39\,\frac{rad}{s}$$

$$\omega_2 = 14.2\,\frac{rev}{s}\left(\frac{2\pi\, rad}{rev}\right) = 89.22\,\frac{rad}{s}$$

According to Law of conservation of Angular momentum.

$$L = L' \text{ or } I_1\cdot\omega_1 - I_2\omega_2 = (I_1 + I_2)\cdot\omega'$$

(minus sign because of clockwise rotation)

$$\omega' = \frac{I_1\cdot\omega_1 - I_2\cdot\omega_2}{I_1+I_2} = \frac{4.25\,kg\cdot m^2\cdot 97.39\,\frac{rad}{s} - 1.8\,kg\cdot m^2\cdot 89.22\,\frac{rad}{s}}{4.25\,kg\cdot m^2 + 1.80\,kg\cdot m^2}$$

Answer: $\omega' = 41.9\,\frac{rad}{s}$ (counterclockwise as viewed from above)

[4] An asteroid revolves around the sun with a mean (average) orbital radius twice that of Earth's orbital radius ($R_{Ast}=2R_{Earth}$). **Find the period of the asteroid (T_{Ast}) in Earth years.**

(Max: 3 Marks, Obtained:_______)

According to Law of Periods: $\frac{T^2}{R^3} = \text{constant}$ or

$$\left(\frac{T_{ast}}{T_{Earth}}\right)^2 = \left(\frac{R_{ast}}{R_{Earth}}\right)^3 \text{ with } R_{ast} = 2R_{Earth}.$$

Hence $$T_{ast} = \left[\left(\frac{R_{ast}}{R_{Earth}}\right)^3\cdot T_{Earth}^2\right]^{1/2} =$$

Answer: $$= \left[\left(\frac{2R_{Earth}}{R_{Earth}}\right)^3\cdot(1.0\,yr)^2\right]^{1/2} \simeq 2.8 \text{ years.}$$

$T_{ast} = 2.8$ years.

[5] Assume that you have a mass of 50.0 kg and Earth has a mass of $5.97*10^{24}$ kg. The radius of Earth is $6.38*10^6$ m. **Find the force of gravitational attraction between you and Earth.**

(Max: 3 Marks, Obtained:_______)

$$F = G\frac{m M_{Earth}}{R^2} =$$

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$$F = \frac{G m \cdot M_{Earth}}{R^2} = \frac{(6.67\times10^{-11} N\cdot m^2/kg^2)\cdot(50.0 kg)\cdot(5.97\times10^{24} kg)}{(6.38\times10^{6} m)^2}$$

$$F \simeq 489 N \simeq 490 N$$

Answer: $F \simeq 489 N \simeq 490 N \simeq 500 N$

[6] A block whose mass *m* is 800 g is attached to a spring having spring constant *k*=80 *N/m*. The block is pulled a distance *x*=10 *cm* from its equilibrium position at *x*=0 *cm* on a frictionless surface and released from rest at *t*=0 *s*. **Find the angular frequency (*w*), the frequency (*f*), the period (*T*), the magnitudes of the maximum speed (v_m) and maximum acceleration (a_m) of the oscillating block. Finally determine the displacement function *x*(*t*) for the spring-block system.**

(Max: 5 Marks, Obtained:________)

$x = x_m \cdot \cos(\omega t + \phi)$ $\quad x(t=0) = x_m = 0.1 \Rightarrow$

$\phi = 0.$ $\boxed{x = 0.1\cdot\cos(\omega t)}$. $T = 2\pi\sqrt{\frac{m}{k}} = 6.28\sqrt{\frac{0.8 kg}{80 \frac{N}{m}}} =$

$T = 6.28\cdot\frac{1}{10} = 0.628 s.$ $\quad f = \frac{1}{T} = \frac{1}{0.628 s} \simeq 1.59 Hz$

$\omega = 2\pi\cdot f = 6.28\cdot1.59 \frac{rad}{s} \simeq 9.99 \simeq 10 \frac{rad}{s}$, $\boxed{x(t) = 0.1\cdot\cos(10\cdot t)}$

Displacement function for the spring-block system.

$V_{max} = \omega\cdot x_m = 10\cdot0.1 \, m/s = 1 \, m/s$

$a_{max} = \omega^2\cdot x_m = 100\cdot0.1 \, m/s = 10 \, m/s^2$

Answer: $\omega \simeq 10 \frac{rad}{s}$, $f \simeq 1.6 Hz$, $T \simeq 0.6 s$, $V_{max} = 1 \, m/s$, $a_{max} = 10 \, m/s^2$, $x(t) = 0.1\cdot\cos(10\cdot t)$.

[7] A 35.0 g bullet moving with a speed v_{b1}=475 *m/s* strikes a 2.5 kg wooden block that is at rest (v_{w1}=0). The bullet passes through the block and leaves it with a final speed v_{b2}=275 *m/s*. **How fast is the wooden block moving (v_{w2}=?) when the bullet leaves it?**

(Max: 4 Marks, Obtained:________)

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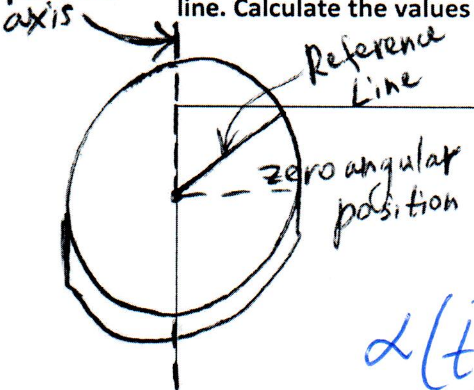
According to Law of Conservation of Linear Momentum

$m_b V_{b1} + m_W V_{W1} = m_b \cdot V_{b2} + m_W \cdot V_{W2}$ with $V_{W1} = 0$.

$V_{W2} = \frac{m_b \cdot (V_{b1} - V_{b2})}{m_W} = \frac{(0.0350\,kg) \cdot (475\,m/s - 275\,m/s)}{2.5\,kg} =$

Answer: $V_{W2} = 2.8\ m/s$.

[8] The disk is rotating about its central axis like a merry-go-round. The angular position $\vartheta(t)$ of a reference line on the disk is given by $\vartheta(t)=-1.00-0.5t+0.3t^2$, with t in seconds and ϑ in radians. **Determine the angular velocity function $w(t)$ and angular acceleration function $\alpha(t)$ for the reference line. Calculate the values of $w(t)$ (in rad/s) and $\alpha(t)$ (in rad/s^2) at $t=10$ s.**



(Max: 5 Marks, Obtained:_______)

$\omega(t) = \frac{d\theta(t)}{dt} = -0.5 + 0.6t$

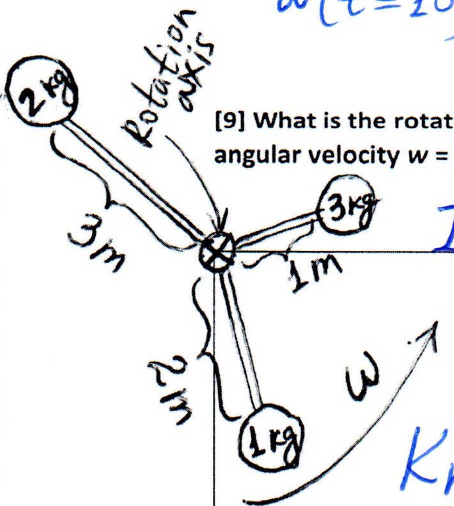
$\omega(t=10s) = -0.5 + 0.6 \cdot 10s = 5.5\ \frac{rad}{s}$

$\alpha(t) = \frac{d\omega(t)}{dt} = 0.6 = constant$

$\alpha(t=10s) = 0.6\ rad/s^2$

Answer: $\omega(t) = -0.5 + 0.6t$, $\alpha(t) = 0.6$,
$\omega(t=10s) = 5.5\ \frac{rad}{s}$, $\alpha(t=10s) = 0.6\ \frac{rad}{s^2}$

[9] What is the rotational kinetic energy (K_{rot}=?) of the device shown below if it rotates at a constant angular velocity w = 60 rad/s?



(Max: 3 Marks, Obtained:_______)

$I = \sum_i m_i R_i^2$

$I = (3\,kg) \cdot (1m)^2 + (2\,kg) \cdot (3m)^2 + (1kg) \cdot (2m)^2 =$

$I = 25\ kg \cdot m^2$

$K_{rot} = \frac{1}{2} I \omega^2 = \frac{1}{2} (25\,kg \cdot m^2) \cdot (60\ \frac{rad}{s})^2 =$

Answer: $K_{rot} = 45000\ J = 45\ kJ$

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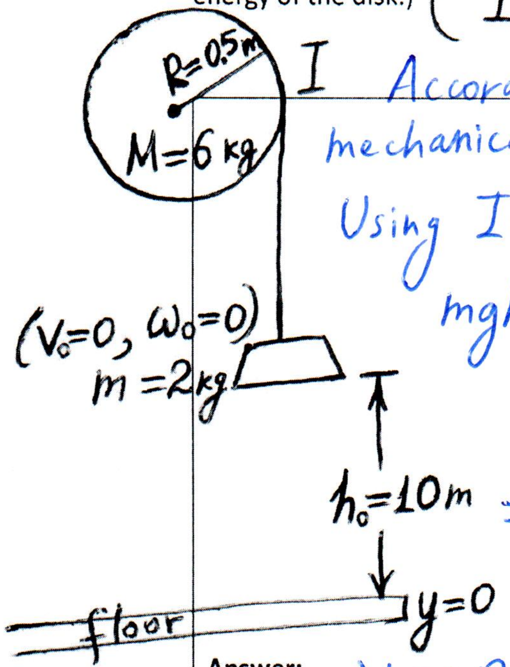
[10] Find the (final) velocity of the 2 kg block (v=?) just before it strikes (touches) the floor. Assume that the rotation of the disk is frictionless. The initial height h_0=10 m, the initial velocity of the block v_0=0 and initial angular velocity of the disk w_0=0. (Use the law of conservation of mechanical energy. Note that the final mechanical energy should include both the kinetic energy of the 2 kg block and rotational kinetic energy of the disk.) $\left(I=\frac{1}{2}MR^2\right)$



(Max: 4 Marks, Obtained:________)

According to Law of conservation of mechanical energy $mgh_0+\cancel{U_{disk}}=\cancel{U_{disk}}+\frac{1}{2}mv^2+\frac{1}{2}I\omega^2$

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

$$mgh_0=\frac{1}{2}mV^2+\frac{1}{2}\left(\frac{1}{2}M\cancel{R^2}\right)\cdot\left(\frac{V^2}{\cancel{R^2}}\right)$$

$$mgh_0=V^2\cdot\left(\frac{m}{2}+\frac{M}{4}\right)$$

$$\Rightarrow V=\sqrt{\frac{mgh_0}{\frac{m}{2}+\frac{M}{4}}}=\sqrt{\frac{2kg\cdot 9.8\frac{m}{s^2}\cdot 10m}{\frac{2}{2}kg+\frac{6}{4}kg}}\simeq 8.9\frac{m}{s}$$

Answer: $V\simeq 8.9\ m/s\simeq 9\ m/s$

[11] The velocity of 625 kg auto is changed from 10 m/s to 44 m/s in 68 seconds (Δt=68.0 s) by an external, constant force (F=constant). **What is the resulting change in momentum of the car (Δp=?)? What is the magnitude of the force (F=?)?**

(Max: 3 Marks, Obtained:________)

$$F=\frac{\Delta p}{\Delta t}=\frac{m\Delta V}{\Delta t}$$

$$\Delta p=m\cdot\Delta V=(625kg)\cdot(44.0\ m/s-10\ m/s)=$$

$$\Delta p\simeq 2,13\times 10^4\ kg.m/s$$

$$F=\frac{m\Delta V}{\Delta t}=\frac{2.13\times 10^4\ kg.m/s}{68.0\ s}\simeq 313\ N.$$

Answer: $\Delta p\simeq 2.13\times 10^4\ kg\cdot m/s$; $F\simeq 313\ N$.

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FORMULA SHEET

$I=\sum_{i=1}^{n} m_i r_i^2$ (Moment of inertia for a system of particles)

$K_{rotation}=\frac{1}{2}I\omega^2$ (Kinetic energy of rotation).

Torque: $\tau=r\cdot F_t=r_\perp\cdot F=r\cdot F\sin\phi$ $\quad \vec{\tau}=\vec{r}\times\vec{F}$

Newton's Second Law in Angular Form: $\tau_{net}=I\cdot\alpha$

(for a single force) $\tau=I\cdot\alpha$

Newton's Second Law: (for a single force) $F=\frac{\Delta p}{\Delta t}=\frac{m\Delta V}{\Delta t}$

$\vec{\tau}_{net}=\frac{d\vec{L}}{dt}$ (system of particles)

$\boxed{F=G\frac{m_1\cdot m_2}{r^2}}$ (Newton's law of gravitation)

$G=6.67\times10^{-11}\ N\cdot m^2/kg^2$

$\boxed{L=I\omega}$ (angular momentum of a rigid body, fixed axis)

If $\tau_{net}=0 \Rightarrow \vec{L}=$ a constant or $\vec{L}_i=\vec{L}_f$ (law of conservation of angular momentum, isolated system)

$I\omega=I'\omega'$ (for a single body)

$F_{net}=\frac{d\vec{P}}{dt}$ and if $F_{net}=0 \Rightarrow \vec{P}=$ constant

or $\vec{P}_i=\vec{P}_f$ (closed, isolated system; the law of conservation of linear momentum)

The law of conservation of linear momentum for collision of two objects:

$$\underbrace{m_1\vec{V}_{1i}+m_2\cdot\vec{V}_{2i}}_{\text{before collision}}=\underbrace{m_1\vec{V}_{1f}+m_2\cdot\vec{V}_{2f}}_{\text{after collision}}$$

$\boxed{V=\omega\cdot R}$

$\boxed{T^2=\left(\frac{4\pi^2}{GM}\right)\cdot R^3 \text{ or } \frac{T^2}{R^3}=\text{constant}}$ (the law of periods)

Good Luck!