College of Arts and Sciences

Department of Mathematics, Statistics, and Physics

Physics Program

PHYS191

Spring 2014

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# PHYS191 Final Exam

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**Student Name: ……**

**Student ID: ……**

**Section number: ……**

**Please read the instructions carefully:**

- Make sure you have 9 pages including the cover page, including 2 parts A and B.
- Part A consist of 10 multiple choice questions where you select only one of the proposed answers.
- Part B consists of four problems that you have to solve all.
- Calculators are permitted, but no electronic dictionaries.
- Mobile devices and cell phones are strictly forbidden.
- All work must be done on exam paper, no loose paper is allowed.
- This is a timed exam (120 minutes). Manage your time and do not spend too much time on any particular question.

**Useful Information:**

$\vec{P} = m\vec{v}$

$\Delta K + \Delta U + \Delta(\text{other energy types}) = 0 \qquad \vec{\mathbf{p}}_A + \vec{\mathbf{p}}_B = \vec{\mathbf{p}}'_A + \vec{\mathbf{p}}'_B$

$E = K + U = constant$

$\Delta\vec{P} = \vec{P}_f - \vec{P}_i$

$\frac{1}{2}m_A v_A^2 + \frac{1}{2}m_B v_B^2 = \frac{1}{2}m_A v_A'^2 + \frac{1}{2}m_B v_B'^2$

$K_{rotational} = \frac{1}{2}I\omega^2$

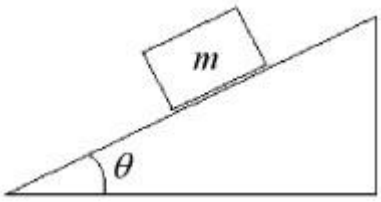
$\boldsymbol{I_{cylinder} = \frac{1}{2}MR^2}, \quad \boldsymbol{I_{sphere} = \frac{2}{5}MR^2}, \quad I_{hoop} = MR^2$

$\boldsymbol{L = I\omega =} \ , \quad \boldsymbol{\vec{L} = \vec{r} \times \vec{p},}$

$\boldsymbol{\vec{\tau} = I\,\vec{\alpha} = \vec{r} \times \vec{F} = \frac{d\vec{L}}{dt}}$

| Angular | Linear |
|---|---|
| $\omega = \omega_0 + \alpha t$ | $v = v_0 + at$ |
| $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$ | $x = v_0 t + \frac{1}{2}at^2$ |
| $\omega^2 = \omega_0^2 + 2\alpha\theta$ | $v^2 = v_0^2 + 2ax$ |
| $\bar{\omega} = \frac{\omega + \omega_0}{2}$ | $\bar{v} = \frac{v + v_0}{2}$ |

1) In the figure, the block of mass m is at rest on an inclined plane that makes an angle $\theta$ with the horizontal. The force of static friction $f$ must be such that




A) $f > mg$.

B) $f > mg\,cos\theta$.

C) $f > mg\,sin\theta$.

D) $f = mg\,cos\theta$.

E) $f = mg\,sin\theta$.

2) A person carries a mass of $10\ kg$ and walks along the +x-axis for a distance of $100m$ with a constant velocity of $2\ m/s$. What is the work done by gravity on the mass?

A) 0 J

B) 20 J

C) 200 J

D) 1000 J

E) None of the other choices is correct.

3) A mass of 3.0 $kg$ is subject to a force $F(x) = 8.0\ N - (4.0\ N/m)x$. The potential energy of the mass is zero at $x = 0$. What is the potential energy of the mass at $x = 2.0\ m$?

A) 4.0 J

B) 0.0 J

C) 8.0 J

D) -4.0J

E) -8.0 J

4) At what rate is a $60.0kg$ boy using energy when he runs up a flight of stairs $10.0m$ high, in $8.00s$?

A) 80.0 W

B) 75.0 W

C) 736 W

D) 4.80 kW

E) 48 W

5) Ahmed and Ali meet in the middle of a lake while paddling in their small boats (each person in a separate boat). They come to a complete stop and talk for a while. When they are ready to leave, Ahmed pushes Ali's boat with a force $\vec{F}$ to separate the two boats. What is correct to say about the final momentum and kinetic energy of the system?

A) The final momentum is in the direction of $\vec{F}$ but the final kinetic energy is zero.

B) The final momentum is in the direction opposite of $\vec{F}$ but the final kinetic energy is zero J.

C) The final momentum is in the direction of $\vec{F}$ and the final kinetic energy is positive.

D) The final momentum is zero kg·m/s and the final kinetic energy is zero J.

E) The final momentum is zero kg·m/s but the final kinetic energy is positive.

6) A $2.00kg$ mass object traveling east at $20.0m/s$ collides with a $3.00kg$ mass object traveling west at $10.0\ m/s$. After the collision, the $2.00kg$ mass has a velocity $5.00\ m/s$ to the west. How much kinetic energy was lost during the collision?

A) 0.00 J

B) 458 J

C) 516 J

D) 91.7 J

E) 175 J

7) Consider a hoop of radius $R$ and mass $M$ rolling without slipping. Which form of kinetic energy is larger, translational or rotational?

A) Translational kinetic energy is larger.

B) Rotational kinetic energy is larger.

C) Both are equal.

D) You need to know the speed of the hoop to tell.

E) You need to know the acceleration of the hoop to tell.

8) A string is wrapped around a pulley with a radius of $2.0\ cm$. The pulley is initially at rest. A constant force of $50\ N$ is applied to the string, causing the pulley to rotate and the string to unwind. If the string unwinds $1.2\ m\ in\ 4.9\ s$, what is the value of the moment of inertia of the pulley?

A) $0.17\ kg \cdot m^2$

B) $17\ kg \cdot m^2$

C) $14\ kg \cdot m^2$

D) $0.20\ kg \cdot m^2$

E) $0.017\ kg \cdot m^2$

9) A merry-go-round spins freely when $Reem$ moves quickly to the center along a radius of the merry-go-round. It is true to say that:

A) the moment of inertia of the system decreases and the angular speed increases.

B) the moment of inertia of the system decreases and the angular speed decreases.

C) the moment of inertia of the system decreases and the angular speed remains the same.

D) the moment of inertia of the system increases and the angular speed increases.

E) the moment of inertia of the system increases and the angular speed decreases.

10) A force at $\vec{F} = 4.00N\hat{\imath} - 3.00N\hat{\jmath}$ is applied to an object at position $\vec{R} = 2.00m\hat{\imath} + 3.00m\hat{\jmath}$ . What is the torque about the origin?

A) $8.00N.m\ \hat{\imath} - 9.00N.m\ \hat{\jmath}$

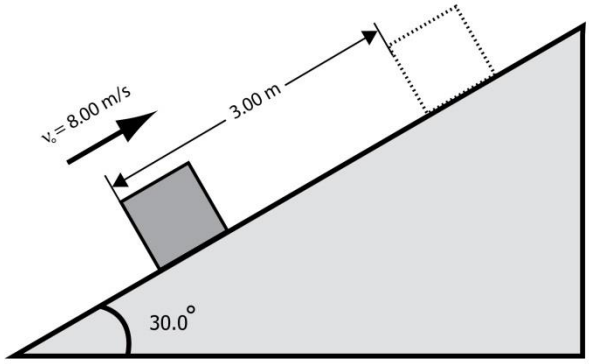
B) $-1.00N.m\ \hat{k}$

C) $8.00N.m\ \hat{\imath} + 9.00N.m\ \hat{\jmath}$

D) $17.0N.m\ \hat{k}$

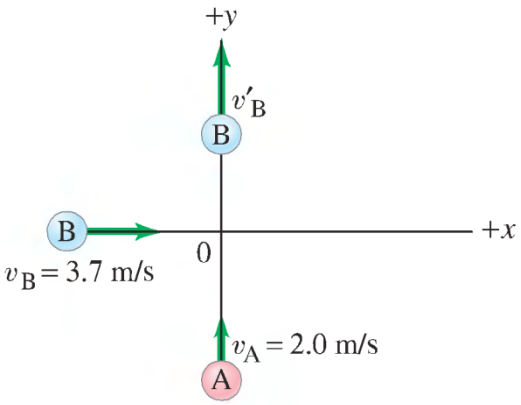
E) $-18.0N.m\ \hat{k}$

**Problem 1) (*5 marks)*** A $5.00kg$ block is set into motion up an inclined plane with an initial speed of $8.00\,m/s$, as in the figure. The block comes to rest after traveling $3.00\,m$ along the plane, which is inclined at an angle of 30.0° to the horizontal. For this motion determine:



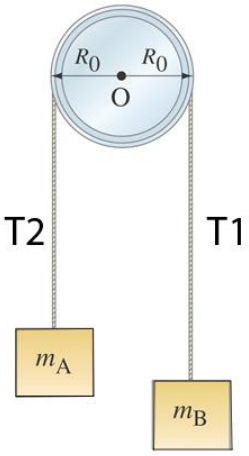

(a) the change in the block's kinetic energy,
(b) the change in the potential energy of the block-Earth system,
(c) the mechanical energy converted due friction,
(d) the friction force exerted on the block (assumed to be constant), and
(e) what is the coefficient of kinetic friction?

**Problem 2) *(5 marks)*** Two billiard balls of equal mass move at right angles and meet at the origin of an xy coordinate system. Initially ball A is moving upward along the y-axis at $2.0\,m/s$, and ball B is moving to the right along the x-axis with speed $3.7m/s$. After the collision (assumed elastic), the second ball is moving along the positive y-axis (See figure).



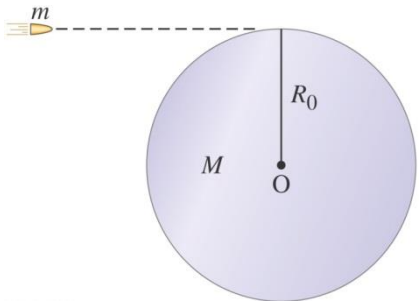

a) What is the speed of ball A after the collision?
b) What is the speed of ball B after the collision?
c) In what direction is ball A moving after the collision?
d) What is the total momentum of the two balls after the collision?
e) What is the total kinetic energy of the two balls after the collision?

**Problem 3) (*5 marks)*** An Atwood machine consists of two masses, $m_a = 19.6\,kg$ and $m_b = 6.30\,kg$, which are connected by an inelastic cord of negligible mass that passes over a pulley. If the pulley, which is approximated as a cylinder, has a mass $m_{pully} = 9.50\,kg$.




a) Derive the equation of the acceleration of the system.
b) Calculate the acceleration of the system.
c) Calculate $\boldsymbol{T_1}$ .
d) Calculate $\boldsymbol{T_2}$ .

**Problem 4) (*5 marks*)** A bullet of mass $m_{bullet} = 7.00g$ moving with velocity $v_{bullet} = 550m/s$ strikes and becomes embedded at the edge of a cylinder of mass $m_{cylinder} = 3.00kg$ and radius $R_o = 30.0cm$. The cylinder, initially at rest, begins to rotate about its symmetry axis, which remains fixed in position. Assume no frictional torque. Calculate:




a) the total angular momentum of the system, with respect to origin, before the collision;
b) the total angular momentum of the system, with respect to origin, after the collision;
c) the angular velocity of the cylinder after this collision;
d) the initial and final kinetic energies;
e) is kinetic energy conserved?