Examination Cover Sheet

COURSE: Mechanics	**NUMBER**: PHYS 204	**SECTION(S)**:	
EXAMINATION: Practice Final	**DATE**:	**Exam Length:** 3 hours	**PAGES**: 8 Including cover
INSTRUCTOR(S):		**DIVISION**: FAS	
MATERIALS ALLOWED: ✓ Booklets ✓ IBM (Scantron) **Blue** ✓ Printed Translation Dictionary ✓ Non-programmable Calculator		**INSTRUCTIONS:** ✓Return all Answer on Exam Open book Crib sheet Details	

Please print your name, I.D. number and section in the appropriate spaces below.

STUDENT NAME: _____

I.D. NO. _____ **SECTION**: _____

SPECIAL INSTRUCTIONS:

1. This is a **closed book** exam. You are NOT allowed to use any resources, including your own formula sheet, notes, or electronic devices.
2. Your exam consists of multiple-choice questions (MCQ) and long answer questions. You do NOT need to provide your work for the MCQ and you will NOT receive partial marks, but your detailed work to the long answer questions MUST be provided. Partial marks may be granted to relevant work.
3. Answers to MCQ should be entered in the **scantron sheet**, using a pencil. Detailed work for long answer questions must be provided in the **answer booklets** provided to you.
4. Upon completing your exam, you MUST return the question booklet, the answer booklet, and the scantron sheet.

Multiple Choice Questions

Answer in the Scantron sheet using pencil. Do NOT provide detailed work.

1. **(2 pts)** Alice and Bob are standing on the rooftop of a 5 m tall building, performing the following experiment: Alice drops a ball of mass 1-kg and at the same time and from the same height, Bob shoots a 0.1-kg bullet horizontally with speed of 500 m/s. Which one hits the ground first? Ignore resistive forces.
   a) The ball
   b) The bullet
   c) They hit the ground at the same time
   d) Cannot be determined

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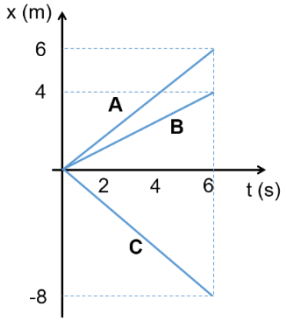
2. **(2 pts)** The graph describes the position of three particles as a function of time, moving in a straight line. Which particle has the largest speed during its motion shown on the graph?
   a) Particle A
   b) Particle B
   c) Particle C
   d) They all have the same speed



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3. **(2 pts)** A 1000-kg car drives up a semicircular hill with a radius of 10 m. With what maximum speed can the car go over the hill without leaving the surface (jumping)? Take $g = 9.8\frac{m}{s^2}$. Round your answer to the nearest integer.
   a) 5 m/s
   b) 10 m/s
   c) 14 m/s
   d) 20 m/s

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4. **(2 pts)** Block A with mass *m* slides on a frictionless floor with constant speed *v*. It then collides with block B with mass *m* which is at rest, and completely sticks to it. What percent of the kinetic energy of block A converts to the kinetic energy of the two blocks after collision?
   a) 100%
   b) 50%
   c) 33%
   d) 25%

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5. **(2 pts)** In car accidents, how do airbags save passenger's life?
   a) They decrease the change in momentum of the passenger, compared to a car with no air bag
   b) They increase the interaction time during which the passenger is brought to rest and hence decrease the force applied on the passenger

c) Airbags do not affect the force applied on the passenger, they only allow more time for the body to adapt to this force.

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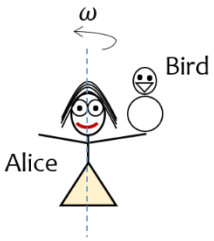
6. **(2 pts)** In a figure skating tournament, Alice is spinning with her arms fully stretched. Suddenly, a bird sits very slowly on her hand. What happens to her angular speed?



a) It increases
b) It decreases
c) It remains constant

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7. **(2 pts)** A ball and a box are placed next to each other on a frictionless inclined surface. If we let them go at the same time, the ball rolls without slipping and the box slides down the inclined surface. Which one will have a larger velocity of center of mass at the bottom of the inclined surface? Although the surface is frictionless, assume that the ball rolls without slipping.
a) The ball
b) The box
c) They will have the same velocity of center of mass since they were released from the same height
d) Cannot be determined

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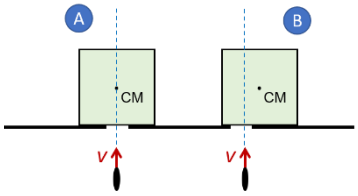
8. **(2 pts)** Two bullets with the same mass and velocity are shot through two boxes that have the same mass. In A, the bullet enters the box along the line passing through its center of mass, while in B it does not, as shown in the figure. If both bullets come to rest inside the boxes, which box will reach a higher height?



a) Box A
b) Box B
c) They will reach the same height
d) It cannot be determined

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9. **(2 pts)** A bar magnet of length L and mass m is spinning about its center of mass with constant angular speed ω on a frictionless surface. We slowly push an identical bar magnet on the surface close to it, until it sticks to the spinning magnet. Ignore the effect of magnetic force and assume it is only responsible to stick the two magnets together. The two magnets (with length $2L$) then spin with angular speed ω' about their center of mass. What is ω'? The moment of inertia of the bar magnet is $I_{CM} = \frac{1}{12}mL^2$.

a) $\omega' = \omega$
b) $\omega' = 4\omega$
c) $\omega' = \frac{\omega}{8}$
d) $\omega' = 8\omega$
e) $\omega' = \frac{\omega}{4}$

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10. **(2 pts)** A mass-spring system is in simple harmonic motion described by $x(t) = 3\cos(2\pi t)$. What is the velocity at $t = \frac{T}{4}$ in m/s?
    a) 0
    b) 6π
    c) -6π
    d) -3
    e) 3

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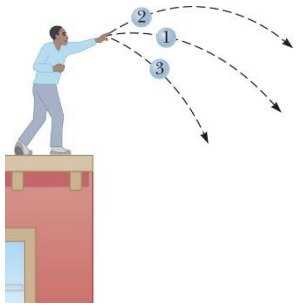
11. **(2 pts)** Three identical balls are thrown from the top of a building, all with the same initial speed. As shown in the figure, the first is thrown horizontally, the second at some angle above the horizontal, and the third at some angle below the horizontal. Neglecting air resistance, which ball will hit the ground with a larger speed?



    a) Ball 1
    b) Ball 2
    c) Ball 3
    d) All three ball will hit the ground with the same speed.

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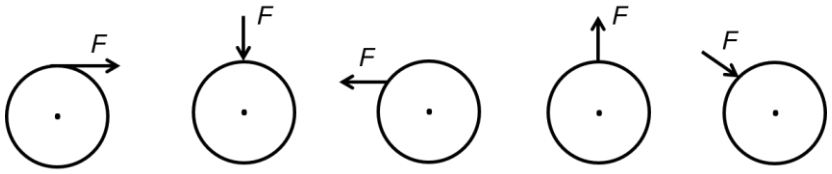
12. **(2 pts)** Five identical cylinders are each acted on by forces of equal magnitude. Which force exerts the biggest torque about the central axes of the cylinders?



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13. **(2 pts)** Two watermelons are dropped from a second-floor physics lab at height h above the ground. Watermelon B has four times the mass of watermelon A ($m_B = 4m_A$). When the watermelons pass the bottom of a first-floor window at height $\frac{h}{4}$ above the ground, the relation between their kinetic energies, K_A and K_B, is:
    a) $K_A = 4K_B$
    b) $K_A = 2K_B$
    c) $K_A = K_B$
    d) $K_B = 2K_A$
    e) $K_B = 4K_A$

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14. **(2 pts)** Two objects have equal kinetic energies. How do the magnitudes of their momenta compare?
    a) $p_1 < p_2$
    b) $p_1 = p_2$

c) $p_1 > p_2$
d) Not enough information to tell

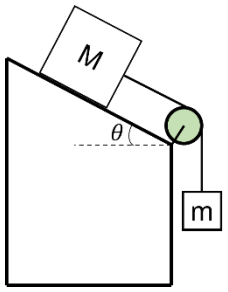
15. **(2 pts)** Alice is standing on a scale inside an elevator that is going upwards and speeding up. The reading of the scale is:
    a) Lower than Alice's weight
    b) Higher than Alice's weight
    c) Same as Alice's weight
    d) Cannot be determined

Long Answer Questions

Provide detailed solutions in the answer booklet

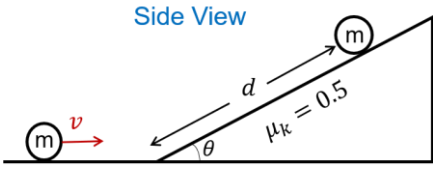
16. Block of mass *M* is connected to hanging mass *m* with a massless string through a pulley, as shown in the figure. The blocks are initially at rest.
    a) **(3 marks)** Draw the free body diagram of each block
    b) **(7 marks)** Find an expression (in terms of *M*, *m*, θ) for the minimum coefficient of static friction, such that the system remains in static equilibrium.

    Show your detailed work.



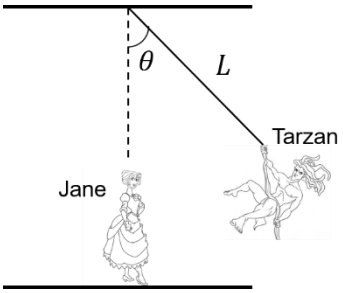
17. **(10 marks)** A cylinder of mass *m*, length *L*, and radius *R* rolls without slipping on a flat surface with $v_{CM} = 5\frac{m}{s}$. The friction between the cylinder and the flat surface is negligible. It then reaches a rough inclined surface ($\theta = 30°$) with $\mu_k = 0.5$. How far up the inclined surface will the cylinder roll? For the cylinder $I_{CM} = \frac{1}{2}mR^2$. Take the resistive force on the cylinder as $\mu_k n$, where n is the normal force on the cylinder. Take $g = 9.8\frac{m}{s^2}$.

    Show your detailed work.

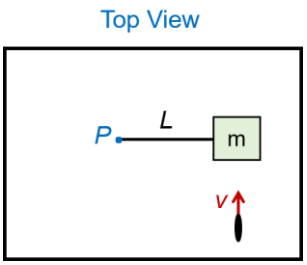


18. **(10 marks)** Tarzan with mass 70 kg swings from a rope of length 5 m which is orginially at angle $\theta = 60°$ with veritcal and grabs Jane (m = 50 kg) at the bottom of his trajectory (when the rope is vertical). What will be the maxium angle the rope makes with vertical after the two of them swing together? Take $g = 9.8\frac{m}{s^2}$.

    Show your detailed work.



19. **(10 marks)** A bullet of mass 200 g is shot with $v = 100\frac{m}{s}$ toward a block of mass 2 kg that is placed on a frictionless table. The block is connected to rod of negligible mass and length 2 m, which is pinned at point *P*. The bullet, which is shot perpendicular to the rod, enters the block, and becomes embedded in it. The system then rotates about point *P* with angular speed ω. What is ω?
Show your detailed work.



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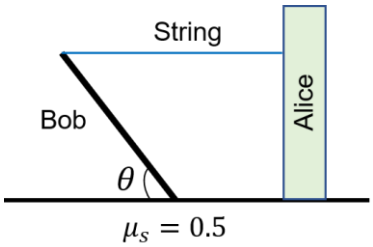
20. Bob wants to do Michael Jackson's *Antigravity* dance move, where he leans forward while keeping his body fully straight. Alice helps him doing the move by holding a massless invisible string tied to his back (the string is horizontal). Model Bob as a uniform straight rod of mass 50 kg and Alice as a wall (see the figure). If the coefficient of static friction between Bob's shoes and the floor is $\mu_s = 0.5$,



a) **(5 marks)** What is the tension in the rope?
b) **(5 marks)** What is the minimum value of θ above which Bob does not slip?
Draw the forces and show your detailed work. Take $g = 9.8\frac{m}{s^2}$.

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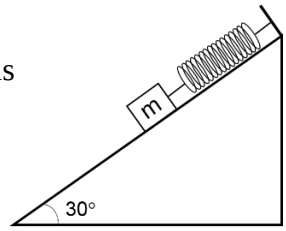
21. A block of mass 2 kg is on a frictionless surface, connected to a light spring with spring constant is $k = 100\frac{N}{m}$. The block is released when the spring has its natural length (neither stretched nor compressed). If the incline angle is 30°:
a) **(5 marks)** What is the maximum elongation of the spring?
b) **(5 marks)** What is the speed of the block sliding down, when the spring is stretched 5 cm?
Show your detailed work. Take $g = 9.8\frac{m}{s^2}$.



Formula Sheet

$$\vec{x}_f = \vec{x}_i + \vec{v}t$$
$$\vec{v}_f = \vec{v}_i + \vec{a}t$$
$$\vec{x}_f = \vec{x}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2$$
$$v_f^2 - v_i^2 = 2a\Delta x$$
$$v_{avg} = \frac{v_1 + v_2}{2}$$
$$\theta_f = \theta_i + \omega t$$
$$\omega_f = \omega_i + \alpha t$$
$$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$$
$$\omega_f^2 - \omega_i^2 = 2\alpha\Delta\theta$$
$$\omega_{avg} = \frac{\omega_1 + \omega_2}{2}$$
$$h = \frac{v_i^2 \sin^2\theta}{2g}$$
$$R = \frac{v_i^2 \sin(2\theta)}{g}$$
$$\sum \vec{F} = m\vec{a}$$
$$f = \mu n$$
$$\vec{P} = m\vec{v}$$
$$\vec{I} = \sum \vec{F}_{avg}\,\Delta t = \Delta\vec{P}$$
$$W = \vec{F}.\Delta\vec{r}$$
$$W = \vec{\tau}.\Delta\vec{\theta}$$
$$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|cos\theta$$
$$|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|sin\theta$$

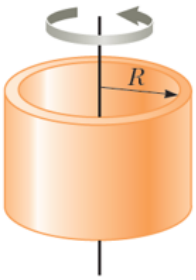
$$K = \frac{1}{2}mv^2$$
$$U_g = mgy$$
$$U_s = \frac{1}{2}kx^2$$
$$\vec{F}_{Spring} = -k\Delta\vec{x}$$
$$K_R = \frac{1}{2}I\omega^2$$
$$v = r\omega$$
$$a = r\alpha$$
$$a_c = \frac{v^2}{r}$$
$$g = 10\ m/s^2$$
$$T = 2\pi\sqrt{\frac{m}{k}}$$
$$\omega = 2\pi f = \frac{2\pi}{T}$$
$$x(t) = A\cos(\omega t + \phi)$$
$$v(t) = -\omega A\sin(\omega t + \phi)$$
$$a(t) = -\omega^2 A\cos(\omega t + \phi)$$

$$I = \sum m_i r_i^2$$
$$\vec{L} = m\vec{r}\times\vec{v}$$
$$\vec{L} = I\vec{\omega}$$
$$\vec{\tau} = \vec{r}\times\vec{F}$$
$$\sum \vec{\tau} = I\vec{\alpha}$$

Table 10.2 **Moments of Inertia of Homogeneous Rigid Objects with Different Geometries**

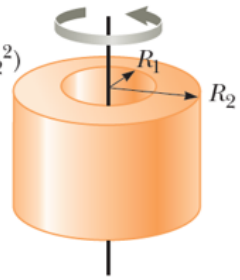
Hoop or thin cylindrical shell

$I_{CM} = MR^2$



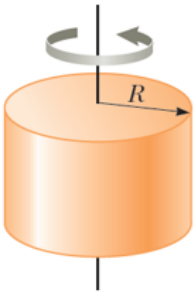
Hollow cylinder

$I_{CM} = \frac{1}{2}M(R_1^2 + R_2^2)$



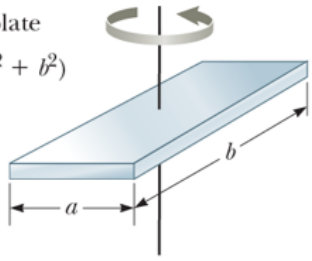
Solid cylinder or disk

$I_{CM} = \frac{1}{2}MR^2$



Rectangular plate

$I_{CM} = \frac{1}{12}M(a^2 + b^2)$

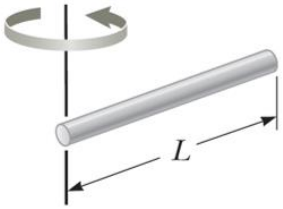


Long, thin rod with rotation axis through center

$I_{CM} = \frac{1}{12}ML^2$

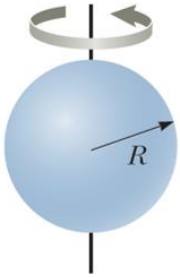
Long, thin rod with rotation axis through end

$I = \frac{1}{3}ML^2$



Solid sphere

$I_{CM} = \frac{2}{5}MR^2$



Thin spherical shell

$I_{CM} = \frac{2}{3}MR^2$