December 2006 Final Examination

VERSION # 1

Mechanics and Waves PHYS-131 – All Sections
December 13, 2006 2 p.m.
Examiner: Prof. Roland Bennewitz Assoc Examiner: Prof. Sangyong Jeon

INSTRUCTIONS:

- This is a CLOSED BOOK examination.
- Only one double-sided CRIB SHEET permitted.
- Part of this examination (questions 1-9) is a MULTIPLE CHOICE examination.
    - The Examination Security Monitor Program detects pairs of students with unusually similar answer patterns on multiple-choice exams. Data generated by this program can be used as admissible evidence, either to initiate or corroborate an investigation or a charge of cheating under Section 16 of the Code of Student Conduct and Disciplinary Procedures.
- MARK YOUR ANSWERS ON THE COMPUTER SHEET USING PENCIL ONLY.
- Make sure you have marked your version number on the computer sheet. Yours is Version 1.
- Answer questions 10-14 into exam booklets.
- You are permitted TRANSLATION dictionaries ONLY.
- Non-programmable calculators without graphic display permitted ONLY.
- This examination consists of 9 multiple choice questions and 5 worked problems on a total of 4 pages, including the cover page.

THIS EXAMINATION IS PRINTED ON BOTH SIDES OF THE PAPER

You can keep the problem sheets if you want.

There are nine multiple choice questions. Only one answer per problem is correct. Each multiple choice problem carries equal weight. The nine multiple choice problems count for 50% of the grade.

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1) Two balls of equal size but different mass are thrown vertically into the air. They start at the same height with the same velocity. Neglect air friction in this problem. Just to make sure: These balls do not collide. Which of the following statements is true?
(a) The ball with the higher mass reaches a larger maximum height.
(b) The ball with the lower mass reaches a larger maximum height.
(c) Both balls reach the same maximum height.
(d) There is not enough information to decide.

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2) Two balls of equal shape but different mass are thrown vertically into the air. They start at the same height with the same velocity. This time, take air friction into account. Just to make sure: These balls do not collide. Which of the following statements is true?
(a) The ball with the higher mass reaches a larger maximum height.
(b) The ball with the lower mass reaches a larger maximum height.
(c) Both balls reach the same maximum height.
(d) There is not enough information to decide,

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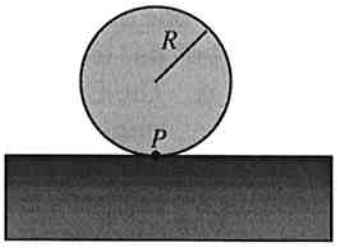
3) The moment of inertia of a solid, homogeneous disk rotating around its center of mass is $I_{CM}=\frac{1}{2}MR^2$, where M is the mass of the disk and R is its radius. The disk is rolling over a surface like a wheel. What is the moment of inertia I_P for the disk with respect to the rotation around the contact point P between disk and surface?



(a) I_P is the same as I_{CM}.
(b) I_P is two times I_{CM}.
(c) I_P is three times I_{CM}.
(d) I_P is four times I_{CM}.
(e) None of the above.

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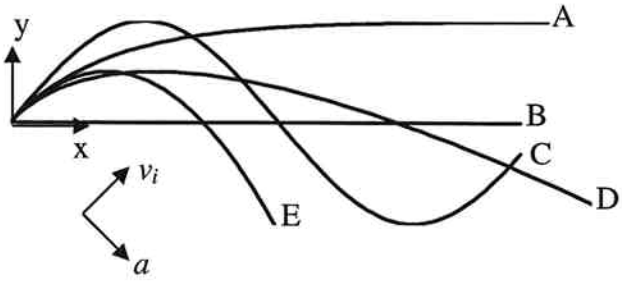
4) Consider the motion of a particle in two dimensions with constant acceleration. The initial velocity v_i has a magnitude of 1 m/s and the constant acceleration a has a magnitude of 1 m/s^2. Their respective directions are indicated in the figure. Which of the lines drawn in the figure resembles the path of the particle closest?



(a) Line A
(b) Line B
(c) Line C
(d) Line D
(e) Line E

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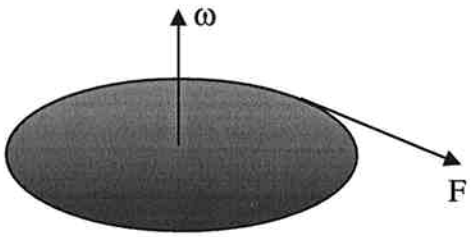
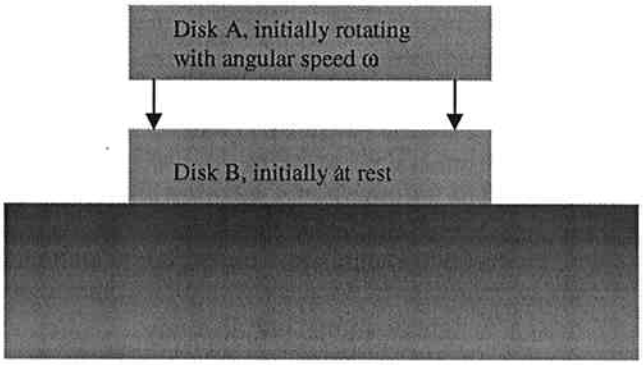
5) A disk is spinning with angular velocity ω. A tangential force acts on the rim of the disk. The direction of velocity and force are given in the figure. With respect to the side of the disk which is visible in the figure, which of the following statements is true:



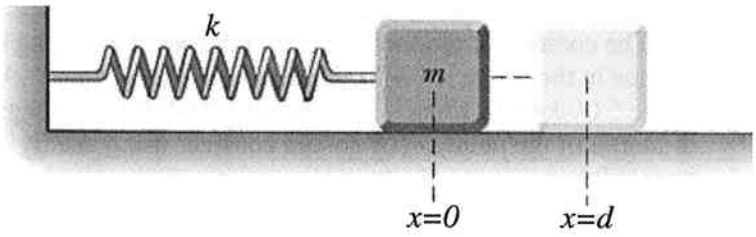
(a) The disk is spinning clockwise with decreasing speed.
(b) The disk is spinning counterclockwise with increasing speed.
(c) The disk is spinning clockwise with increasing speed.
(d) The disk is spinning counterclockwise with decreasing speed.
(e) Not enough information to decide which of the above statements is true.

6) A medium-size car is traveling at a speed of 50 km/h. Which of the following values is the closest to the kinetic energy of the car?
(a) 1.5×10^{-5} J
(b) 1.5 J
(c) 1.5×10^{5} J
(d) 1.5×10^{10} J
(e) 1.5×10^{15} J

7) A rotating Disk A is placed rim-on-rim onto an identical Disk B which is initially at rest. Due to friction forces, Disk A stops rotating with respect to Disk B after some time. The question is whether Disk B will start rotating and if yes at what angular speed the two combined disks will rotate.
Some more details: Disk B sits on a frictionless surface.
Initially, Disk B is at rest and Disk A is rotating with angular speed ω about the vertical axis through its center of mass.
Which of the following statements is true:
(a) The angular momentum is conserved in this system and Disk A and B will rotate with angular speed ω.
(b) The angular momentum is conserved in this system and Disk A and B will rotate with angular speed $\omega/2$.
(c) In order to calculate the angular speed of the combined disks one needs to know the details of the frictional forces.
(d) Disk B will not start to rotate at all.
(e) None of the above is true.



8) A cube of mass m rests on a horizontal surface. The static coefficient of friction is μ_s, the kinetic coefficient of friction is μ_k. The cube is attached by a light spring with spring constant k to a wall. By applying a horizontal force, the cube is moved by a distance d away from its original position. Due to static friction, it rests in its new position.
Which of the following statements is true:
(a) The work done by the force on the cube is $\frac{1}{2}kd^2$.
(b) The work done by the force on the cube is $\frac{1}{2}kd^2+mg\mu_k d$.
(c) The work done by the force on the cube is $\frac{1}{2}kd^2+mg\mu_k d+mg\mu_s$.
(d) The work done by the force on the cube is $\frac{1}{2}kd^2+mg(\mu_k+\mu_s)d$.
(e) None of the above statements is true.



9) The amplitude of a transversal mechanical wave is doubled, with no other changes made to the wave. As a results of this doubling, which of the following statements is correct?
(a) The speed of the wave changes.
(b) The frequency of the wave changes.
(c) The maximum transverse speed of an element of the medium changes.
(d) All of (a)-(c) are true.
(e) None of (a)-(c) is true.

There are five worked problems. Each worked problem carries equal weight. The five worked problems count for 50% of the grade. Write your complete solution into the exam booklet. Write readable! If we cannot read your answer, we cannot give you credit!

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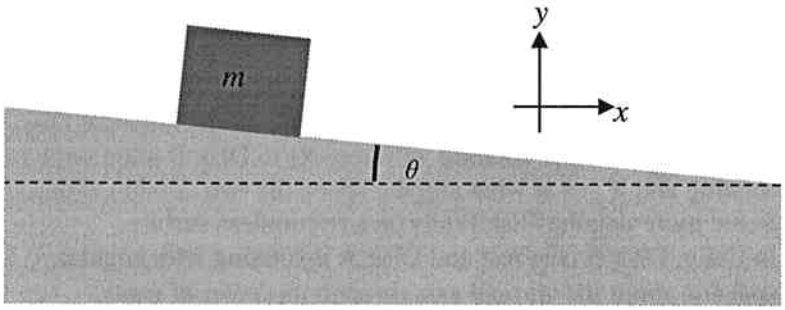
10) A cube with mass $m=1.00\ kg$ is resting on an inclined plane which forms an angle $\theta = 10.0^o$ with the horizontal. A static friction force prevents it from sliding down the incline.
(a) Draw the free-body diagram for the cube.
(b) Calculate the static friction force acting on the cube. Your result must be a vector, write down its components. You must use the coordinate system indicated in the figure.
Use $g=9.80\ m/s^2$ for your calculation.



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11) The radius of the Earth is $R_E=6.37\times10^6$ m. The gravitational constant is $G=6.67\times10^{-11}$ Nm^2/kg^2. The free-fall acceleration at the surface of the Earth is $g=9.80$ m/s^2. Using these three numbers, find the average density of the Earth. (The volume V of a sphere with radius r is given by $V=4/3\ \pi r^3$)

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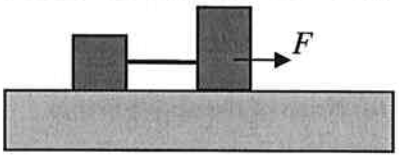
12) Two bodies with a mass of 2.00 kg and 3.00 kg are connected by a light string. They move on a horizontal frictionless surface. A horizontal force F of 5.00 N is applied to the 3.00-kg body.
(a) What is the acceleration of the two bodies?
(b) What is the tension in the string?



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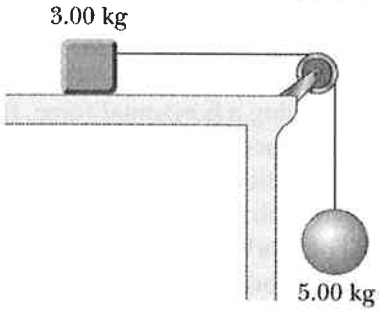
13) The coefficient of kinetic friction between the 3.00 kg block and the surface in the figure is 0.400. The system starts from rest. What is the speed of the 5.00-kg ball when it has fallen 1.70 m? You can neglect the moment of inertia of the pulley. You should consider using energy conservation in your solution.



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14) A pendulum is made from a mass $m_1=1.00$ kg suspended in a string of $l=1.00$ m length. Initially, the mass m_1 is at rest. A second mass $m_2=1.00$ kg is hitting m_1 with a speed of $v_2=1.00$ m/s. At the instant of the collision $(t=0)$ there is no velocity component in vertical direction. The collision is perfectly inelastic; the two masses stick together. The resulting oscillatory motion of the pendulum can be described as $\theta(t)=\theta_0 sin(\omega t)$, where θ is the angle the pendulum forms with the vertical. Calculate ω and θ_0. You can treat the masses as particles. Use $g=9.80$ m/s^2.