Good Luck!

Exam 2 Review

Phys 221 – Supplemental Instruction, Noah
Announcements

• Fill out Evaluation (even if you don't come to SI regularly)
• Interested in leading? Let me know.
Exam Overview

• About 1/3 of the problems will stress conceptual understanding
  - Don’t waste too much time on these
  - Think carefully!
• Remaining 2/3 will be numerical problems to test ability to apply these concepts
  - Know your formula sheet
  - Rule out wrong answers
• 27 Questions, 2 hours (4.4 minutes/problem)
Prepare Yourself

• Practice Problems!!
  - Practice tests (11 of them, with solutions)
    • It’s really easy to think you understand a concept, but then find out you can’t solve a problem on it.
    • If you miss a problem, read the solution, then do it again later without the solution.
  - Old quizzes (make sure you understand mistakes)
  - Book problems (have answers in the back)
  - SI worksheets
  - Recitation problems

• Concepts
  - Textbook
  - Online Summaries
  - Lecture Slides
Resources

- Session Tuesday
- Reviews by Dr. Whisnant on Wednesday
- Help Room
Can you do the following:
Energy

- Work kinetic energy theorem
- Potential energy
- Conservative/non-conservative forces
- Energy diagram
- Energy in spring and simple pendulum systems
- Work
- Power
Collisions

• Momentum and its conservation
• Impulse
• Average force
• Elastic/inelastic collisions
• Ballistic pendulum (just a collision problem)
Rotational Concepts

- Center of Mass
- Moments of Inertia
  - Parallel axis theorem
- Torque
- Statics
- Rotational energy
- Rolling (with and without slipping)
- Angular Momentum and its conservation
- Massive pulleys
Gravitation/Other

- Pressure
- Gravitation (calculate force of gravity away from Earth’s surface)
- Gravitational potential energy
- Escape Velocity
- Kepler’s laws
The test may not be cumulative, but the concepts are!

Remember, physics builds upon itself. If you struggled with a concept in Exam 1, make sure you understand it before taking this test.
Energy Problems
34. A box with mass \( m = 3 \) kg is released on a frictionless incline at height \( h = 2.4 \) m over the ground as shown in the figure below. The incline has an angle of \( 30^\circ \) with the horizontal. The horizontal is a rough surface and has a coefficient of kinetic friction of \( \mu_k = 0.2 \). What distance \( d \) does the box slide on the horizontal before it comes to a stop?

a. 7.2 m  
b. 12.0 m  
c. 18.0 m  
d. 24.0 m  
e. 32.4 m
40. A mass can move along the $x$ axis and the only force that acts on it is the one associated to the potential energy depicted in the figure below.

In two separate experiments, the mass is released from rest at points $A$ ($U = 40$ J) and $B$ ($U = 30$ J). Consider in each case the maximum kinetic energy that the mass will achieve, $KE_{A\text{-max}}$ and $KE_{B\text{-max}}$.

What is the difference between these maximum kinetic energies, $KE_{A\text{-max}} - KE_{B\text{-max}}$?

A. 0.0 J  
B. 10 J  
C. 20 J  
D. 30 J  
E. 40 J
33. A particle slides towards the right along a frictionless track under the influence of gravity as shown in the figure. The particle starts with non-zero kinetic energy at position A, then slides past positions B and C and eventually slides past position D. Position B is at height $y = 0$. The positive y-axis points upwards. The arrows next to the particle at the two indicated positions are velocity unit vectors showing the direction of motion of the particle at these two positions. At which position A, B, C, or D of the particle is the mechanical energy of the particle the largest? (Ignore any effects due to air friction)

A. The mechanical energy is the same at all four positions.
B. A
C. B
D. C
E. D
Energy Diagrams

- “The mechanical energy of an object can be the result of its motion (i.e., kinetic energy) and/or the result of its stored energy of position (i.e., potential energy). The total amount of mechanical energy is merely the sum of the potential energy and the kinetic energy.”

- Potential Energy is given on diagram
- Total Energy is decided from starting conditions (is it at rest initially?)
- Kinetic Energy is the distance between the total energy and potential energy at a point.
Given a PE Graph

- Where are the stable and unstable equilibriums?
- At what points is the force zero?
- At what points is the force negative?
- Where does the particle have maximum speed, if it’s released at x=4?
29. A 0.5 kg toy falls from a window. When the toy is 10 m above the ground, its speed is 5.0 m/s. Right before hitting the ground, its speed is 9.0 m/s. Find the work done by air resistance during these last 10 m of its drop.

A. −14 J
B. −35 J
C. −40 J
D. −49 J
E. −98 J
Kinetic Energy

• Remember there are two types:
  - Rotational KE = $\frac{1}{2} I \omega^2$
  - Translational KE = $\frac{1}{2} mv^2$ (velocity of center of mass)
Collision Problems
Do they tell you it’s elastic, inelastic, or completely inelastic?

Yes

No

Does the problem say the objects stick together after the collision?

Yes

It’s *completely inelastic* (KE not conserved)

No

What is the change in Kinetic Energy of the collision?

0

Elastic

Greater than 0

Inelastic (could be completely inelastic, but doesn’t have to be)

Is it an elastic collision?
43. Two masses, A = 2.0 kg and B = 3.0 kg, slide along an air track without friction. Initially, A is located at \(x = 0.0\) m and has a velocity of 12 m/s in the positive x direction, and B is located at \(x = 1.0\) m and has a velocity of 5.0 m/s, also in the positive x direction. After they collide, A has a velocity of 4.0 m/s in the positive x direction.

How much kinetic energy was lost as a result of the collision?

A. 170 J
B. 83 J
C. 17 J
D. 5.3 J
E. 0.0 J
Is momentum conserved then?

- The law of momentum conservation can be stated as follows. For a collision occurring between object 1 and object 2 in an isolated system, the total momentum of the two objects before the collision is equal to the total momentum of the two objects after the collision.

  - Isolated system = no outside forces
What about angular momentum?

• Angular momentum is conserved when
  - The external torque on the object is zero
36. Two blocks slide on a frictionless surface in the positive $x$ direction. Block 1 has mass $m_1$ and block 2 has mass $m_2 = 2m_1$. Before the two blocks collide, block 1 has velocity $v_1 = 6 \text{ m/s}$ and block 2 has velocity $v_2 = v_1/2$. After the collision, which is elastic, the velocity of block 1 is _____.

a. $-2 \text{ m/s}$
b. $0 \text{ m/s}$
c. $2 \text{ m/s}$
d. $3 \text{ m/s}$
e. $5 \text{ m/s}$
34. Cart A with mass $m_A$ and cart B with mass $m_B = 2m_A$, respectively, are initially at rest compressing a massless spring. After they are released and cart B separates from the spring as shown, cart A has a final speed of $v_A$. The final speed of cart B is $v_B = \text{_____}$. 

A. $2v_A$
B. $v_A$
C. 0
D. $v_A/2$
E. $v_A/3$
Impulse

- Defined as $J$.
  - Change in momentum
  - Integral of force over time
  - Average force times change in time
  - Impulse of A on B is equal and opposite to the impulse of B on A.
Rotational Problems
Center of Mass

Discrete: $I = \sum m_i r_i^2$
Discrete: $L = \sum r \times mv$

Continuous: $I = \int r^2 dm$
Continuous: $L = I \omega$
32) The cross section of a piece of metal of uniform density is shown in the figure below. The y-position of the center of mass of the piece is at _____.

A) 0.7 m
B) 0.8 m
C) 0.9 m
D) 1.0 m
E) 1.1 m
Moments of Inertia

- Always around an axis!
- Disks are just flat cylinders!
- Parallel Axis Theorem
  - $I = I_{cm} + Md^2$
A solid cube of mass $M$ and side-length $L$ is rotating about an axis along one of its edges as shown. The moment of inertia of the cube about its axis of rotation is $I = \text{[answer]}$. [The moment of inertia of the solid cube about a fourfold rotational symmetry axis through its center is $I_{cm} = (1/6)ML^2$]

A. $(1/6)ML^2$
B. $(1/3)ML^2$
C. $(1/2)ML^2$
D. $(2/3)ML^2$
E. $ML^2$
| Linear |
|----------------|-----------------|
| \( \alpha \) (Linear acceleration) | \( \alpha \) (Angular acceleration) |
| \( m \) (Mass) | I (Moment of Inertia) |
| \( F = mv \) (Equation for force) | \( \tau = l\omega \) (Equation for torque) |
| \( P = mv \) (Definition of linear momentum) | \( \tau = r \times F \) (Equation relating force and torque) |
| \( KE_{trans} = \frac{1}{2} m v^2 \) (Definition of translational KE) | \( KE_{rot} = \frac{1}{2} I \omega^2 \) (Definition of rotational KE) |
| \( F = \frac{dp}{dt} \) (Force-momentum relation) | \( F = \frac{dp}{dt} \) (Torque-angular momentum relation) |
| \( \Delta P = \int F \cdot dt \) (Impulse equation) | \( \Delta L = \int \tau \cdot dt \) (Angular Impulse equation) |
| \( P = Fv \) (Power and constant force, constant velocity relation) | \( P = \tau \omega \) (Power and constant torque, constant angular velocity relation) |
| \( W = \int F \, dx \) (Work caused by force) | \( W = \int \tau \, d\theta \) (Work caused by torque) |
43) A light triangular plate $OAB$ lies in the horizontal plane. Three forces, $F_1 = 3.0 \text{ N}$, $F_2 = 1.0 \text{ N}$, and $F_3 = 9.0 \text{ N}$, act on the plate, which can rotate freely about a vertical axis through point $O$. The net torque around point $O$ is closest to

A) 1.4 Nm  
B) 1.1 Nm  
C) 1.8 Nm  
D) 0.8 Nm  
E) 1.6 Nm
A 10-kg uniform ladder, 5.0 m long, is placed against a smooth wall at a height of \( h = 3.1 \) m. The base of the ladder rests on a rough horizontal surface whose coefficient of static friction is 1.50. An 80-kg block is suspended from the top rung of the ladder, very close to the wall. The force exerted on the wall by the ladder is closest to:

A) 830 N  
B) 1500 N  
C) 1300 N  
D) 1100 N  
E) 660 N
A 100kg sign is to be attached to the end of a long beam. A massless cable is attached to the beam at a distance of $x = 1.5$ meters at an angle of 20 degrees. If the beam is 200 kg and 5 meters long, what is the tension in the cable? Assume the beam is mechanically fastened to the wall.
46. A 3.00-kg mass hangs from a light string that is wound around a 4.00-kg disk with a radius of 30.0 cm. If the mass starts at rest, how fast is it moving after it descends by 1.00 m?

A. 2.90 m/s  
B. 3.43 m/s  
C. 3.96 m/s  
D. 4.43 m/s  
E. 7.84 m/s
Gravitation/Fluids Problems
52) Consider an object that drops a distance $h$ in a time of 66 s on the surface of the earth (neglecting air effects). How long would it take the same object to drop the same distance on the surface of Pluto? The mass of Pluto is $1.1 \times 10^{22}$ kg and its radius is $4.0 \times 10^{5}$ m. The mass of Earth is $5.97 \times 10^{24}$ kg, and the radius of Earth is $6.38 \times 10^{6}$ m.

A) 120 s
B) 66 s
C) 34 s
D) 96 s
E) 54 s
51) The Moon does not crash into Earth because:

A) the Moon is in Earth’s gravitational field
B) the net force on the Moon is zero
C) the Moon is beyond the main pull of Earth’s gravity
D) the Moon is being pulled by the Sun as well as by Earth
E) none of the above
Gravitation

• Equation relating the period of a planet’s motion around a star of mass $M$

  - NOTE: $r$ is the distance between the two masses, $M$ is the mass of the object being orbited.
53. A 30.0-kg cube has dimensions of 0.500 m on a side. A hand holds the cube at rest completely under water at a depth of 10.0 m below the surface. When released, what is the initial acceleration of the block? The density of water is 1000 kg/m³.

A. 9.81 m/s² downward
B. 4.90 m/s² downward
C. 4.90 m/s² upward
D. 31.1 m/s² upward
E. 40.8 m/s² upward
31) An 8.0 gram bullet is shot into a 4.0 kg block, which initially is at rest, on a frictionless horizontal surface. The bullet remains lodged in the block. The block moves into a spring and compresses it by 5.1 cm. The force constant of the spring is 1900 N/m. The initial velocity of the bullet is closest to:

A) 560 m/s  
B) 600 m/s  
C) 580 m/s  
D) 530 m/s  
E) 620 m/s
29. A child fires a marble of mass $m$ with a spring-loaded toy cannon vertically up. The child stretches the spring with spring constant $k$ by a distance $\Delta x$ and the marble reaches a height $h$ ($h \gg \Delta x$) after the spring is released. For a second shot with the same cannon the child stretches the spring twice as far and uses a marble with twice the mass of the first marble. The second marble reaches a height of _____.

a. $h/4$
b. $h/2$
c. $h$
d. $2h$
e. $4h$
47. Three identical solid cylinders of mass $M$ and radius $R$ are used in the system shown below. Two of them (1 and 3) are attached to a massless, ideal string that goes through their center of mass, and roll without slipping on either side of a double incline. The last cylinder (2) can only rotate about its axis and is used as a pulley. The string does not slip on the pulley. If cylinder #1 rolls up the incline with speed $v$, what is the total kinetic energy of the system?

- a. $\frac{3}{2}Mv^2$
- b. $\frac{5}{2}Mv^2$
- c. $\frac{3}{4}Mv^2$
- d. $\frac{5}{4}Mv^2$
- e. $\frac{7}{4}Mv^2$
43. A 7.00-kg lamp has a 60-W light bulb in it. If left on for 15.0 minutes, this bulb uses an energy equivalent to lifting the lamp to what height above the ground?

A. 7.00 m  
B. 13.1 m  
C. 15.0 m  
D. 60.0 m  
E. 786 m
48. A carousel has a radius of 3.0 m and a moment of inertia of 3000 kg-m$^2$. The carousel is rotating unpowered and without friction with an angular velocity of 1.2 rad/s. An 80-kg man with a velocity of 5.0 m/s, on a line tangent to the rim of the carousel, as shown in the figure. When the man reaches the carousel he grabs onto the edge and hangs on. What is the final angular velocity of the carousel after the man jumps on, in rad/s?

A) 0.97  
B) 1.2  
C) 1.3  
D) 1.4  
E) 5.0
46. A uniform solid disk of radius 1.6 m and mass 2.3 kg rolls without slipping to the bottom of an inclined plane. The inclined plane makes an angle of 10° with the horizontal. What is the force of friction acting in the disk, in N? You may assume that the coefficient of static friction is large enough to keep the disk from slipping.

A) 1.3  
B) 2.6  
C) 3.9  
D) 5.2  
E) 6.5
42. A 4.6-m massless rod is loosely pinned to a frictionless pivot at point P. A 2.3-kg ball is attached to the other end of the rod (see figure). The ball is held at point A, where the rod makes a 30-degree angle above the horizontal, and is released from rest. The ball-rod assembly then swings freely in a vertical circle. What is the tension in the rod, in N, when the ball reaches the lowest point at B?

A) 29
B) 107
C) 68
D) 45
E) 90
35) A girl of mass 57 kg throws a ball of mass 0.7 kg against a wall. The ball strikes the wall horizontally with a speed of 29 m/s, and it bounces back with this same speed. The ball is in contact with the wall 0.05 s. What is the average force exerted on the wall by the ball?

A) 410 N  
B) 17,000 N  
C) 33,000 N  
D) 66,000 N  
E) 810 N
40) A solid disk and a solid sphere are released simultaneously at the top of an inclined plane. They roll down without slipping. Which will reach the bottom first?

A) The one of greatest mass.
B) The sphere.
C) The one of smallest diameter.
D) The disk.
E) They will reach the bottom at the same time.
41) A block of mass of $m = 4.0 \text{ kg}$ is attached to a light string, which is wrapped around a spool of radius $R = 0.5 \text{ m}$ and mass of $M = 4.0 \text{ kg}$. The spool, which can be regarded as a hollow cylinder, is suspended from the ceiling, and the block is then released from rest a distance $4.80 \text{ m}$ above the floor. The angular speed of the spool, when the block hits the floor, is closest to

A) 16 rad/s  
B) 14 rad/s  
C) 12 rad/s  
D) 10 rad/s  
E) 8.0 rad/s
A large horizontal uniform solid circular disk of mass $M = 4.00 \text{ kg}$ and radius $R = 1.00 \text{ m}$ is rotating about its continuous symmetry axis at an angular speed $\omega_1 = 24.0 \text{ rad/s}$ as shown in the top panel of the figure. The disk is supported from below on an axle at its center like a merry-go-round. Now a ball of mass $m = 1.00 \text{ kg}$ is dropped onto the rim of the disk and sticks to it as shown in the bottom panel of the figure. The final angular speed of the disk and ball is $\omega_2 = \text{_____} \text{ rad/s}$. [A circular disk is a thin cylinder. The moment of inertia of a uniform solid cylinder about its continuous rotational symmetry axis is $I_{cm} = (1/2)MR^2$.]

A. 8  
B. 12  
C. 16  
D. 20  
E. 24