Exam 2 Practice Problems

TIPS:

- If you want to print these questions, simply press `Ctrl + P` while on this page, and it should come out formatted nicely.
- If any of the math content isn't rendering properly, please refresh the page and it should be fixed.
  - *(e.g. you see something like `$v=\sqrt{2gh}$` instead of $v = \sqrt{2gh}$)*

Difficulty key:

- ★☆☆ = beginner
- ★★☆ = standard
- ★★★ = challenging / multi-step

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[1] Energy, Work, and Conservation

[1.1] Work and Kinetic Energy

1. ★☆☆
   A 0.40-kg stone is dropped from rest from a cliff 11.0 m high. Neglect air resistance. What is its speed just before it hits the ground?
2. ★☆☆
   An 18.0-kg sled starts from rest on a horizontal frictionless surface. A constant 48.0-N force pulls it through 7.50 m. What is the sled’s final speed?

3. ★★☆
   A 10.0-kg crate is pulled up a 6.00-m incline at 25.0° above the horizontal by a force of 95.0 N parallel to the incline. The coefficient of kinetic friction is 0.18. The crate starts from rest. What is its speed at the top?

[1.2] Potential Energy and Springs

1. ★★☆
   A 2.50-kg block is pressed against a horizontal spring with spring constant 320 N/m, compressing the spring by 0.180 m. The surface is frictionless. What is the maximum speed of the block after it is released?
2. ★★☆
   A 5.0-kg block is released from rest at a height of 2.40 m above a horizontal surface. The curved ramp is frictionless, but the horizontal surface has coefficient of kinetic friction 0.30. How far does the block slide along the horizontal surface before coming to rest?
3. ★★★
   A 4.00-kg block starts from rest and slides 5.00 m down a 30.0° incline. The coefficient of kinetic friction between the block and the incline is 0.10. At the bottom of the incline there is a spring with spring constant 900 N/m aligned along the incline. How much does the spring compress before the block momentarily stops?

[1.3] Mixed Energy Problems

1. ★★★
   A 65.0-kg snowboarder starts with a speed of 4.0 m/s at the top of a hill that is 18.0 m above the bottom. During the descent, friction dissipates 6.0 × 10^3 J of mechanical energy. What is the snowboarder’s speed at the bottom?
2. ★★★
   A 1.20-kg cart is released from rest at the top of a frictionless track 1.50 m above the bottom. It then crosses a 0.80-m rough patch with coefficient of kinetic friction 0.25 before

compressing a horizontal spring with spring constant 250 N/m. What is the maximum compression of the spring?

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[2] Momentum, Impulse, and Collisions

[2.1] Momentum and Impulse

1. ★☆☆
   A 0.145-kg baseball is moving 18.0 m/s east when it is struck by a bat and leaves moving 32.0 m/s west. What is the ball's change in momentum? Give magnitude and direction.
2. ★☆☆
   A 2.0-kg hockey puck moving 6.0 m/s on frictionless ice is brought to rest in 0.20 s by a constant force. What are the impulse delivered to the puck and the magnitude of the average force?

[2.2] One-Dimensional Collisions

1. ★★☆
   A 1.20-kg cart moving 3.5 m/s to the right collides and sticks to a 0.80-kg cart initially at rest. What is their common speed immediately after the collision? How much kinetic energy is lost?
2. ★★☆
   A 0.020-kg bullet embeds in a 4.0-kg wooden block resting on a frictionless table. Immediately after the collision, the block and bullet move together at 1.5 m/s. What was the bullet's speed just before impact?

[2.3] Two-Dimensional Collisions and Explosions

1. ★★☆
   A 70.0-kg runner moving east at 6.0 m/s is tackled by an 80.0-kg runner moving north at 5.0 m/s. They stick together. What are the magnitude and direction of their velocity immediately after the collision?
2. ★★★
   Identical billiard balls are used on a frictionless table. A cue ball moves east at 2.4 m/s and strikes a stationary target ball. After the collision, the target ball moves at 1.6 m/s at 40.0° south of east. What is the velocity of the cue ball immediately after the collision?
3. ★★★
   A 4.0-kg cart moving east at 5.0 m/s explodes into two pieces. One 1.5-kg piece moves west at 2.0 m/s immediately after the explosion. What are the magnitude and direction of the velocity of the other piece?
4. ★★★
   A 6.0-kg firework shell is initially at rest and explodes into three pieces. Two 2.0-kg pieces fly off symmetrically, each moving at 8.0 m/s and 30.0° below the horizontal, one to the left and one to the right. What is the velocity of the third piece?

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[3] Rotation

[3.1] Rotational Kinematics

1. ★☆☆
   A disk starts from rest and rotates with a constant angular acceleration of 2.5 rad/s^2 for 4.0 s. Find its final angular speed and angular displacement.

2. ★☆☆

   A wheel initially rotating at 12.0 rad/s slows uniformly to 4.0 rad/s in 6.0 s. Find its angular acceleration and the number of revolutions it makes during that interval.

3. ★★☆

   A rotor speeds up uniformly from 3.0 rad/s to 15.0 rad/s while turning through 54 rad. What are the angular acceleration and the time required?

4. ★★★

   A platform starts from rest, accelerates uniformly until it reaches 18.0 rad/s, and then continues rotating at that constant speed for 5.0 s. During the entire motion it turns through 126 rad. How long did the platform spend accelerating?

[3.2] Rotational Energy and Rolling

1. ★☆☆

   A 3.0-kg solid cylinder of radius 0.20 m rolls without slipping at 4.0 m/s. What is its total kinetic energy?

2. ★★☆

   A uniform solid sphere starts from rest and rolls without slipping down a 5.0-m ramp inclined at 25.0° above the horizontal. What is its speed at the bottom?

3. ★★☆

   A hoop and a solid disk have the same mass and radius and are released from rest from the same height h. Which one reaches the bottom first? For each object, express the speed at the bottom in terms of g and h.

4. ★★★

   A 3.0-kg solid sphere is rolling without slipping at 5.0 m/s on a level floor and then starts up a hill. Neglect losses. What maximum vertical height does it reach before coming momentarily to rest?

[3.3] Angular Momentum

1. ★☆☆
   A student on a frictionless swivel stool has an initial moment of inertia of 2.8 kg·m^2 and is rotating at 1.6 rad/s. After pulling two dumbbells inward, the student's moment of inertia decreases to 1.9 kg·m^2. What is the new angular speed?
2. ★★☆
   For the situation in the previous problem, by what factor does the student's rotational kinetic energy change?
3. ★★☆
   Disk A has moment of inertia 1.50 kg·m^2 and angular velocity +8.0 rad/s. Disk B has moment of inertia 0.80 kg·m^2 and angular velocity −5.0 rad/s. They are gently pressed together and rotate as one unit. What is their common final angular velocity?
4. ★★★
   A 0.050-kg lump of clay moving tangentially at 12.0 m/s strikes and sticks to the rim of a turntable of radius 0.30 m. The turntable is initially at rest and has moment of inertia 0.20 kg·m^2. What is the angular speed of the turntable-clay system just after the collision?

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[4] Torque and Static Equilibrium

[4.1] Torque Basics

1. ★☆☆
   A mechanic applies a 40.0-N force perpendicular to the end of a 0.30-m wrench. What is the magnitude of the torque about the bolt?
2. ★☆☆
   A meter stick is pivoted at its center. A 15.0-N upward force is applied 0.30 m to the right of the pivot, and a 10.0-N downward force is applied 0.20 m to the left of the pivot. What is the net torque on the stick? State magnitude and direction.

[4.2] Static Equilibrium: Beams and Cables

1. ★★☆
   A uniform 6.0-m beam of mass 40.0 kg is hinged to a wall at its left end and held horizontal by a vertical cable attached at the right end. A 25.0-kg sign hangs 4.5 m from the hinge. What is the tension in the cable?
2. ★★☆
   A 5.0-m uniform beam of mass 120 kg is hinged to a wall and makes a 30.0° angle above the horizontal. It is supported by a cable attached to the far end of the beam and perpendicular to the beam. An 80.0-kg crate hangs from the far end. What is the tension in the cable?
3. ★★★
   A 5.0-m ladder of mass 12.0 kg leans against a frictionless wall, making a 60.0° angle with the floor. The floor is rough enough to prevent slipping. A 70.0-kg person stands 3.0 m up the ladder as measured along the ladder from the bottom. Find the horizontal force exerted by the wall on the ladder and the friction force at the floor.
4. ★★★
   A uniform 4.0-m beam of mass 50.0 kg is hinged to a wall at its left end and held horizontal by a cable attached to its right end. The cable makes a 35.0° angle above the beam. A 20.0-kg bucket hangs from the far end. Find the cable tension and the horizontal and vertical components of the hinge force.

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[5] Springs and Simple Harmonic Motion

[5.1] Spring Constants and Basic SHM Quantities

1. ★☆☆

   A 0.250-kg mass hangs from a vertical spring and stretches it 0.040 m from its natural length. What is the spring constant?

2. ★☆☆

   A 0.80-kg block attached to a spring with spring constant 200 N/m oscillates on a frictionless horizontal surface. Find its period and frequency.

3. ★★☆

   The position of an oscillator is given by $x(t) = 0.12\cos(4\pi t)$ with x in meters and t in seconds. Find the amplitude, period, and maximum speed.

4. ★★☆

   A 0.40-kg block attached to a horizontal spring with spring constant 160 N/m oscillates with amplitude 0.10 m. What are its maximum speed and maximum acceleration?

[5.2] Energy in SHM

1. ★★☆

   A 0.50-kg block hangs from a vertical spring with spring constant 80 N/m. It is pulled 0.15 m below equilibrium and released from rest. What is its speed when it is 0.05 m above equilibrium?

2. ★★★

   A 0.300-kg mass is attached to a spring hanging from the ceiling and is released from rest when the spring is unstretched. The mass falls 0.180 m before momentarily coming to rest for the first time. What is the spring constant?

3. ★★★

   A 1.20-kg block rests on a frictionless incline at 20.0° and is attached to a spring of constant 90.0 N/m oriented along the incline. The block is displaced 0.12 m from equilibrium and released from rest. What are the period of the motion and the maximum speed?

[6] Mixed Exam-Style / Multi-Concept Review

1. ★★☆
   A 3.0-kg block on a horizontal surface is connected over a pulley to a hanging 2.0-kg block. The coefficient of kinetic friction between the 3.0-kg block and the table is 0.20. The pulley has mass 1.5 kg and moment of inertia $I = \frac{1}{2}MR^2$. The string does not slip. Find the acceleration of the system and the tension on each side of the pulley.

2. ★★★
   A 0.80-kg cart is launched from rest by a spring with spring constant 200 N/m compressed 0.20 m on a frictionless track. It collides and sticks to a 1.20-kg cart initially at rest. The combined carts then move up a frictionless incline. What maximum vertical height do they reach?

3. ★★★
   A uniform 3.0-m beam of mass 18.0 kg is hinged to a wall at one end and held horizontal by a cable attached at the free end. The cable suddenly snaps. What is the beam's initial angular acceleration just after the cable breaks?

4. ★★★
   A 0.50-kg block attached to a horizontal spring with spring constant 100 N/m oscillates with amplitude 0.12 m. As it passes through equilibrium, it collides and sticks to a 0.25-kg block initially at rest on the same frictionless surface. What is the amplitude of the motion immediately after the collision?