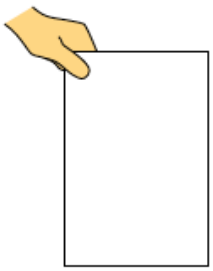
Physics 8, Fall 2011, Homework #99.

Due in 1W12 DRL at 5pm, Friday, December 99, 2099

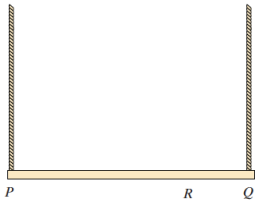
1A. The spacecraft in the movie 2001: A Space Odyssey has a rotating cylinder to create the illusion of gravity, inside of which the crew walks and exercises. (a) If the radius of the cylinder is about three times a crew members height, what should the rate of revolution of the cylinder be in order to replicate Earths gravity? (b) For a person standing in this cylinder, what is the difference between the gravitation acceleration at the top of her head and the gravitational acceleration at her feet?

1B. Two clocks, which both keep accurate time on Earth, are taken to Mars. One clock is based on the oscillation of a spring, the other on a pendulum. Mars has a mass about 1/10th that of the Earth and a radius about one half as large as Earth's. (a) Does the oscillating-spring clock keep the same time on Mars as it kept on Earth? Explain. (b) Does the pendulum clock keep the same time on Mars as it kept on Earth? Explain. (c) Do the two clocks agree with each other on Mars? If so, explain. If not, determine by what factor one clock is faster than the other.

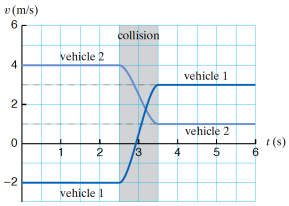
2A. You are holding a sheet of paper at rest between your thumb and index finger as shown at right. The sheet has a mass of 0.005 kg and its dimensions are 0.20 m by 0.30 m. (a) Is the earth (via gravity) exerting a torque on the sheet about the top-left corner? If so, what is the magnitude of this torque? (b) Are you exerting a torque on the sheet about the top-left corner? If so, what is the magnitude of this torque?



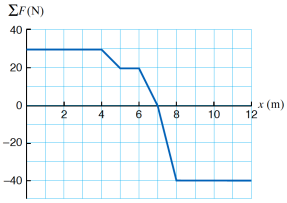
2B. A uniform plank is supported by two ropes at points P and Q. The tension in the rope at P is 150 N. The point at which the other rope is attached is now moved to point R, which is halfway between Q and the center of the plank. What are the tensions in the two ropes?



3A. The graph at right shows the velocities of two vehicles traveling along the same straight line. Around 3 s the two vehicles collide. The mass m_1 of vehicle 1 is 1200 kg. (a) Determine the mass m_2 of vehicle 2. Explain how you determined your answer. (b) Is the collision between the vehicles elastic, inelastic, or totally inelastic? Explain how you determined our answer. If the collision is elastic, describe the motion of the two vehicles. If it is inelastic, determine how much energy is dissipated in the collision. (c) Determine the magnitude of the average force exerted by vehicle 1 on vehicle 2 during the collision and the magnitude of the average force exerted by vehicle 2 on vehicle 1 during the collision.



3B. Starting from rest at $x = 0$ m, a 15 kg object is subject to a variable force in the x direction. The magnitude of the vector sum of the forces exerted on the object varies with *position* as shown in the graph. (a) How long does it take the object to get to $x = 4$ m from $x = 0$ m? (b) How much work is done in moving the object over this distance? (c) What is the object's speed at $x = 4$ m? (d) What is the total work done on the object in going from $x = 0$ m to $x = 12$ m?

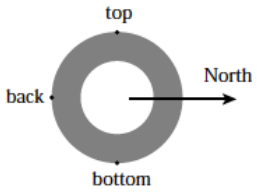


4A. A 2.0 kg ball is suspended from a spring, stretching the spring by 0.50 m from its relaxed length. The ball is then pulled down an additional 0.20 m from its equilibrium position and then released. How long after being released does the ball pass its equilibrium position?

4B. A block of mass $m_1 = 1.0$ kg hangs on a vertical spring and oscillates with frequency $f = 1.0$ Hz. With an additional block of mass m_2 added to the spring, the frequency is half as large: 0.5 Hz. What is m_2?

5A. A hollow cylinder, a solid cylinder, and a billiard ball are all released at the top of a ramp and roll to the bottom without slipping. (a) On the way down, rank them according to the fraction of the kinetic energy that is rotational, from least to greatest. (b) What are the ratios of their speeds when they reach the bottom of the ramp?

5B. A car with wheels of 0.60 m diameter travels North at 10 m/s. (a) What are the magnitude and direction of the angular velocity of the wheels? How long does it take for a wheel to complete one rotation? (b) In the reference frame of the Earth, what is the magnitude and direction of the velocity at the following points on the wheel? (i) at the top of the wheel? (ii) at the bottom of the wheel? (iii) at the back of the wheel? (c) If the wheel is a uniform cylinder of mass 20 kg, what is the total kinetic energy of all four wheels?



6A. You have been hired to check the technical correctness of an upcoming made-for-TV murder mystery. The mystery takes place in the space shuttle. In one scene, an astronaut's safety line is sabotaged while she is on a space walk, so she is no longer connected to the space shuttle. She checks and finds that her thruster pack has also been damaged and no longer works. She is 200 meters from the shuttle and moving with it. That is, she is not moving with respect to the shuttle. There she is drifting in space with only 4 minutes of air remaining. To get back to the shuttle, she decides to unstrap her 10 kg tool kit and throw it away with all her strength, so that it has a speed of 8 m/s. According to the script, she makes it back to the shuttle before running out of air. Is this correct? Her mass, including space suit (but without the tool kit) is 80 kg.

6B. A space shuttle of inertia m is attached to a booster rocket that has an inertia nine times as large. This system is moving at a speed of 800 m/s in outer space. Then explosive bolts are detonated, separating the shuttle from the rocket and thrusting the shuttle forward at a speed of 100 m/s relative to the rocket. What are the velocities of the rocket and shuttle right after the explosion?

7A. A target is dropped at the same time that a rifle is fired at it. The target and the rifle are a horizontal distance of 100 m apart and the target is initially 50 m above the ground. The rifle is at ground level. (a) Assuming you can fire bullets with whatever velocity you wish, at what angle above the horizontal must you aim so that the bullet hits the target? Is the angle you obtain the only angle or the minimum angle for hitting the target? Explain. (b) If you aim at the angle you obtained in part (a), what is the minimum speed at which you can fire bullets and still hit the target? (c) If you fire your bullet at 50 m/s, how far does the target fall before it gets hit?

7B. To push a 25 kg crate up a 45° frictionless incline, a worker exerts a *horizontal* force of 426 N until the crate has slid 3.6 m up the incline. The crate starts from rest. (a) Calculate the final velocity of the crate. (b) Calculate ΔK and ΔU for the crate. (c) Which forces (or components of those forces) do work on the crate? Calculate the work done by each of these forces and hence the total work done on the crate. How does this work compare to your answers to part (b)? Explain.

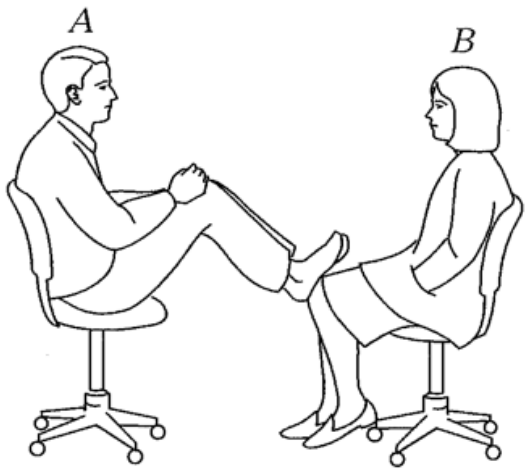
8A. A satellite that is always over the same spot on the earth is called "geostationary." Geostationary orbits are located above the equator and have an orbital period of 24 hours. How far above the center of the earth is a geostationary orbit?

8B. The moon's orbit around the earth is approximately circular, with a period of 27.3 days. How far is the moon from the earth? (Need mass of earth for this.)

9A. Explain why, when a truck makes a sharp turn on an unbanked road, the wheels on the inside of the turn tend to come off the ground.

9B. A 51 kg child riding a bike puts all her weight on each pedal when climbing a hill. The pedals rotate in a circle of radius 20 cm. (a) What is the maximum torque she exerts? (b) How could she exert more torque?

aA. In the figure below, student A has a mass of 75 kg and student B has a mass of 57 kg. They sit in identical office chairs facing each other. Student A places his bare feet on the knees of student B, as shown. Student A then suddenly pushes outward with his feet, causing



both chairs to move. During the push and while the students are still touching one another,

1. neither student exerts a force on the other
2. student A exerts a force on student B, but B does not exert any force on A
3. each student exerts a force on the other, but B exerts the larger force

4. each student exerts a force on the other, but A exerts the larger force

5. each student exerts the same amount of force on the other

aB. Two metal balls are the same size but one weighs twice as much as the other. The balls roll off of a horizontal table at the same instant and with the same speed. In this situation

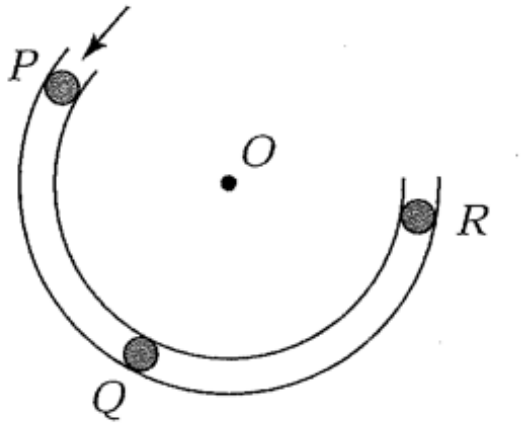
1. both balls hit the floor at approximately the same horizontal distance from the base of the table.

2. the heavier ball hits the floor at about half the horizontal distance from the base of the table as does the lighter ball.

3. the heavier ball hits the floor considerably closer to the base of the table than the lighter ball, but not necessarily half the horizontal distance.

4. the lighter ball hits the floor considerably closer to the base of the table than the heavier ball, but not necessarily at half the horizontal distance.

bA. The accompanying figure shows a frictionless channel in the shape of a segment of a circle with its center at O. The channel has been anchored to a frictionless horizontal table top. You are looking down at the table. Forces exerted by the air are negligible. A ball is shot at high speed into the channel at P and exits at R.



Consider the following distinct forces:

1. a downward force of gravity

2. a force exerted by the channel pointing from Q to O

3. a force in the direction of motion

4. a force pointing from O to Q

Which of the above forces is (are) acting on the ball when it is within the frictionless channel at position Q?

1. A only.

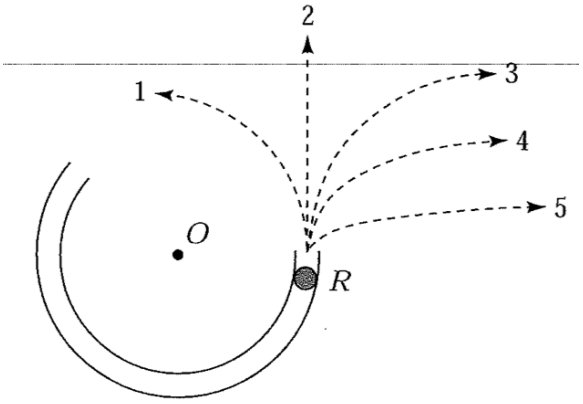
2. A and B.

3. A and C.

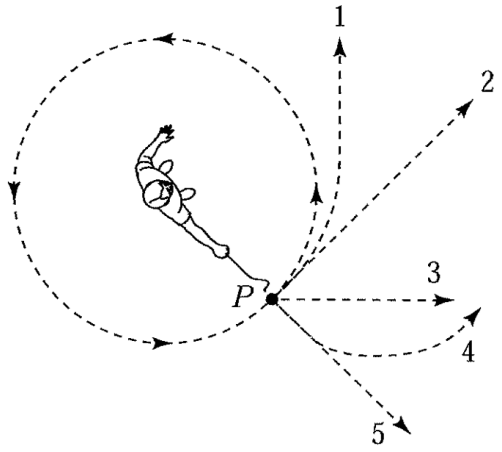
4. A, B, and C.

5. A, C, and D.

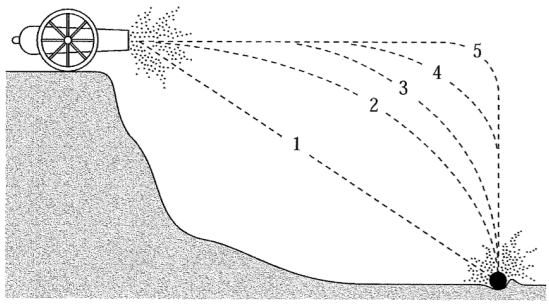
Which of the paths 1–5 below would the ball most closely follow after it exits the channel at R and moves across the frictionless table top?



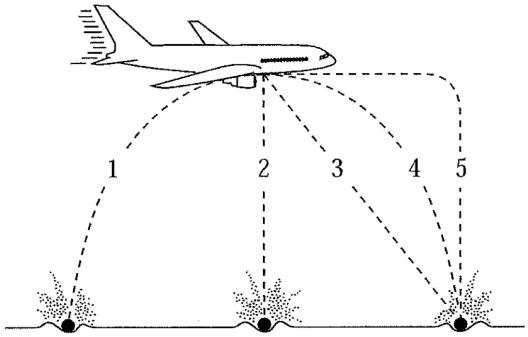
bB. A steel ball is attached to a string and is swung in a circular path in a horizontal plane as illustrated in the figure below. At point P, the string suddenly breaks near the ball. If these events are observed from directly above, which of the 1–5 paths below would the ball most closely follow after the string breaks?



cA. A ball is fired by a cannon from the top of a cliff, as shown below. Which of the paths 1–5 would the cannon ball most closely follow?

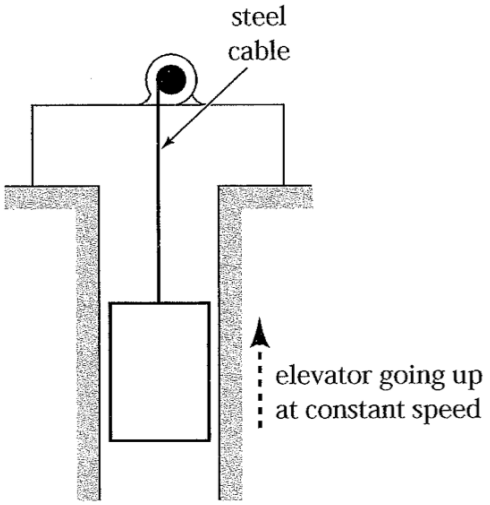


cB. A bowling ball accidentally falls out of the cargo bay of an airliner as if flies along in a horizontal direction. As observed by a person standing on the ground and viewing the plane as in the figure below, which of the paths 1–5 would the bowling ball most closely follow after leaving the airplane?

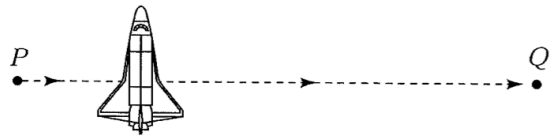


dA. An elevator is being lifted up an elevator shaft at a constant speed by a steel cable, as shown in the following figure. All frictional effects are negligible. In this situation, forces on the elevator are such that

1. the upward force by the cable is greater than the downward force of gravity.
2. the upward force by the cable is equal to the downward force of gravity.
3. the upward force by the cable is smaller than the downward force of gravity.
4. the upward force by the cable is greater than the sum of the downward force of gravity and a downward force due to the air.
5. none of the above. The elevator goes up because the cable is being shortened, not because an upward force is exerted on the elevator by the cable.



dB. A spaceship drifts sideways in outer space from point P to point Q, as shown below. The spaceship is subject to no outside forces. Starting at position Q, the spaceship's engine is turned on and produces a constant thrust (force on the spaceship) at right angles to the line PQ. The constant thrust is maintained until the spaceship reaches point R in space.



Which of the paths 1–5 below best represents the path of the spaceship between points Q and R?