Physics 8, Fall 2011, Homework #12.

Due in 1W12 DRL by 5pm, Friday, December 9, 2011

I encourage you to discuss physics topics with your classmates, but you should complete all of these problems on your own.

Times listed are a guideline for the final exam.

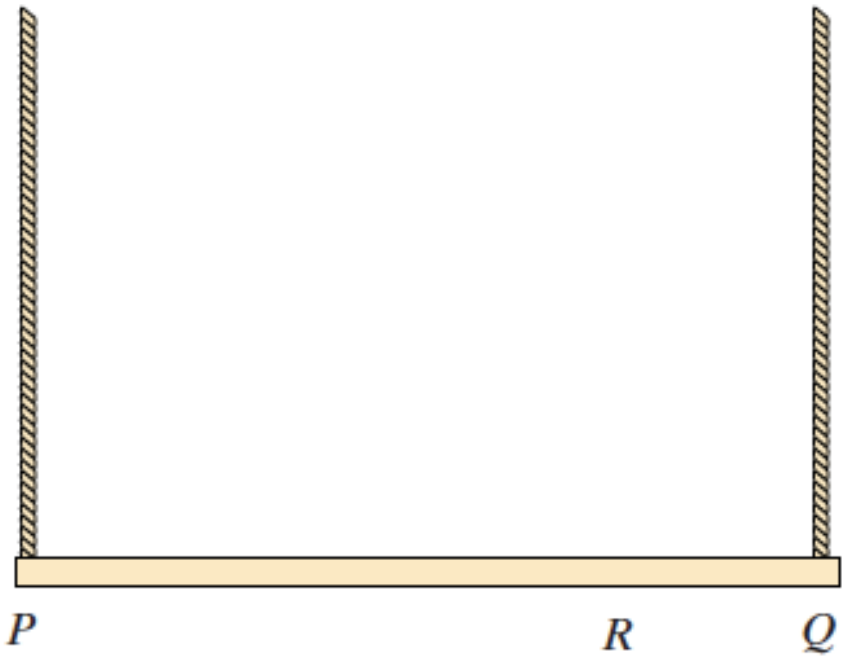
1. (15 minutes, 10%) Two clocks, which both keep accurate time on Earth, are taken to Mars. One clock is based on the oscillation of a spring, the other on a pendulum. Mars has a mass about 1/10th that of the Earth and a radius about one half as large as Earth's.

(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.

2. (7 minutes, 5%) 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?



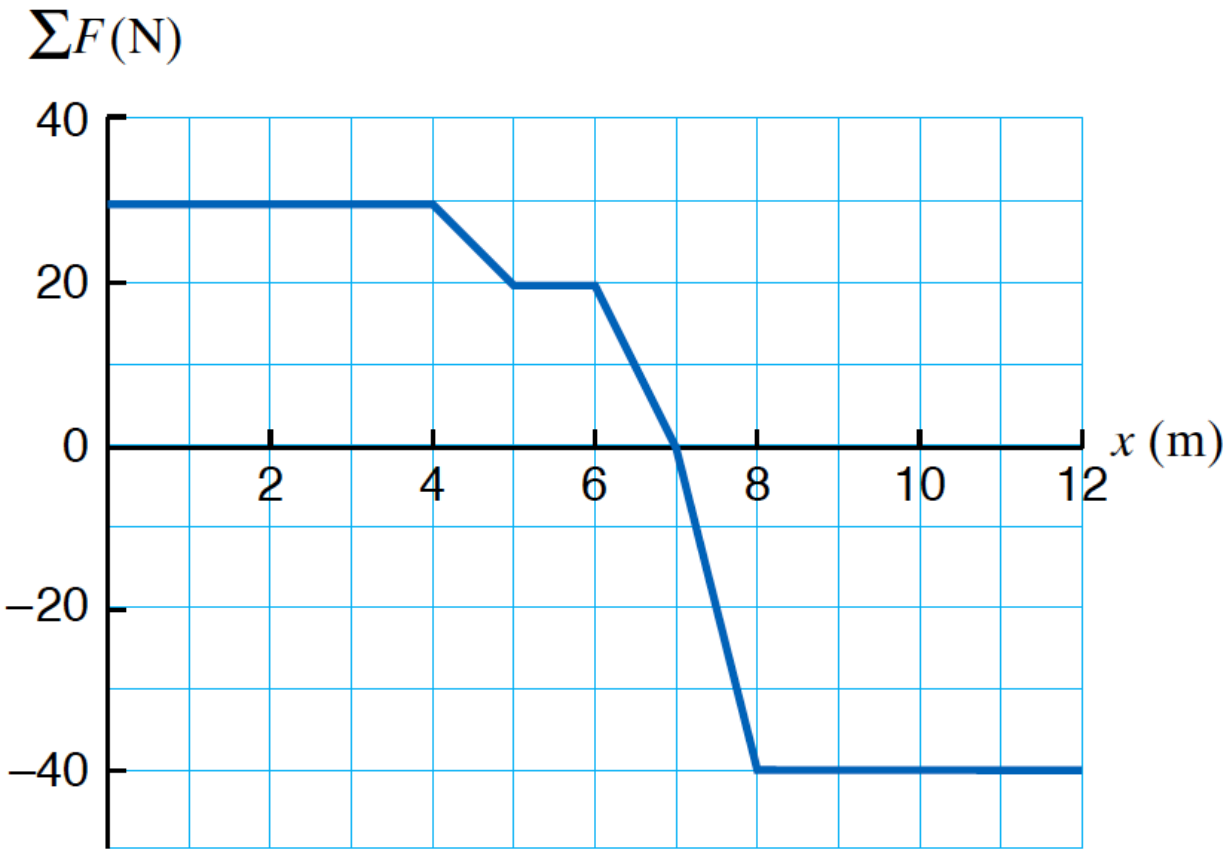
3. (12 minutes, 10%) Starting from rest at $x = 0$ m, a 15 kg object is subject to a variable force in the x direction. The magnitude of the vector sum of the forces exerted on the object varies with *position* as shown in the graph.

(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?



4. (7 minutes, 5%) 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?

5. (20 minutes, 15%) 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?

6. (12 minutes, 10%) 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?

7. (25 minutes, 20%) 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?

8. (7 minutes, 5%) 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? (Newton's G is $6.67 \times 10^{-11}\ \frac{\text{N m}^2}{\text{kg}^2}$, and the mass of the earth is 6.0×10^{24} kg.)

9. (5 minutes, 5%) A 51 kg child riding a bicycle 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?

Conceptual questions: 10 minutes total, 15%

C1. 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,

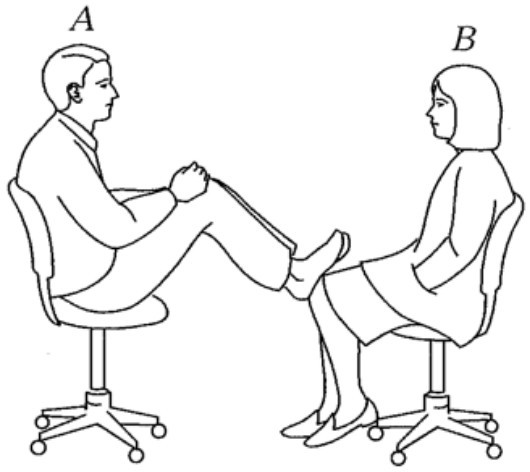
A. neither student exerts a force on the other

B. student A exerts a force on student B, but B does not exert any force on A

C. each student exerts a force on the other, but B exerts the larger force

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

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



Briefly explain your choice.

C2. 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.

(a) Which of the following forces is (are) acting on the ball when it is within the frictionless channel at position Q? Briefly explain your choice(s).

A. a downward force of gravity

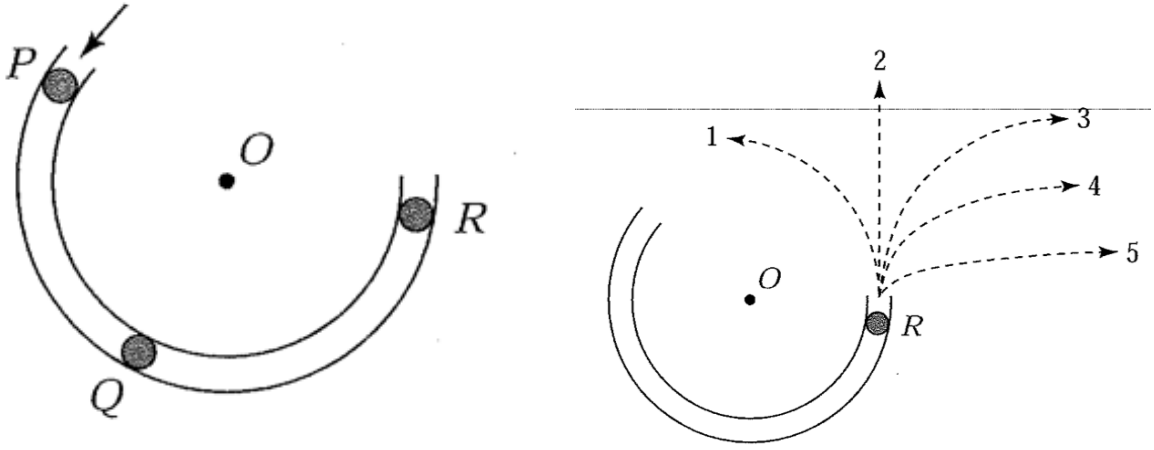
B. a force exerted by the channel pointing from Q to O

C. a force in the direction of motion

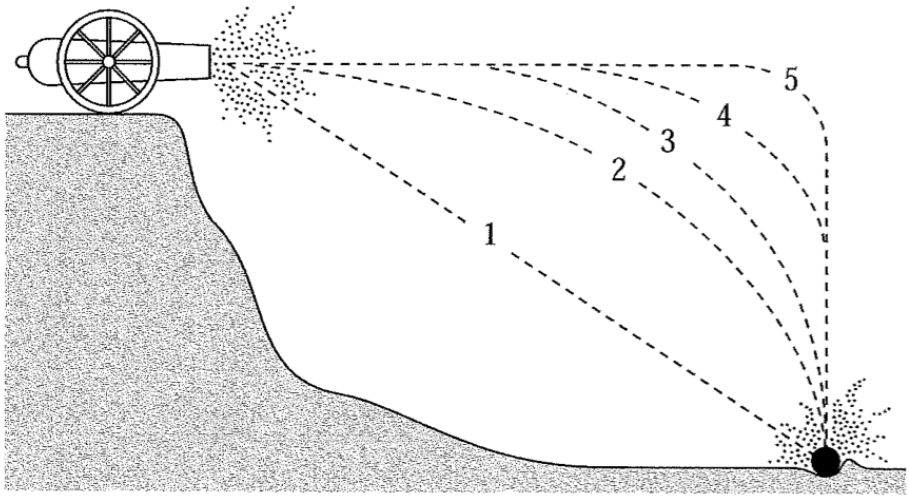
D. a force pointing from O to Q

E. an upward force exerted by the channel to oppose the force of gravity

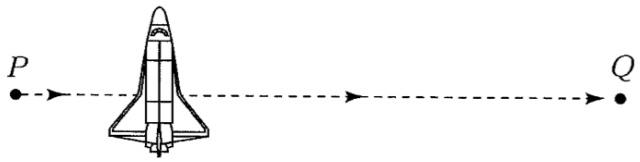
(b) Which of the paths 1–5 below would the ball most closely follow after it exits the channel at R and moves across the frictionless table top? Briefly explain your choice.



C3. 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? Briefly explain your choice.



C4. 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 a right angle 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? Briefly explain your choice.