

Name: _____

PHYS 1210-02 Exam 2
Standards 16–28

Calculators of any type are permitted. You may bring your own 8 ½" × 11" notes sheet, which may contain information on both sides, and a duck. Each question is worth one point unless otherwise indicated.

Enter your answer to a free response question inside the box provided for the question. Include units with all quantitative answers. Do not make stray marks in the box, and do not write your answer outside the box. **Answers written outside the box will not be credited.** Show your work in the space provided with the question. It is a good idea to write your answers in pencil.

If the question asks for a single selection from provided options, **fill** the circle (○) by the most correct answer. If the question asks you to select all appropriate options, **fill** the squares (□) by all correct options. Do not check, mark an “X,” circle, or otherwise indicate your choices. If you want to revoke a choice, fully erase the mark.

1. (3 points) A crewed lander makes its initial descent to the Moon’s surface. At its distance, the lander with crew weighs 16,000 newtons in the Moon’s gravitational field. Fill in the blanks to complete the sentences describing this descent.

The exerts a force with a magnitude of 16,000 newtons on the lander. This force is directed toward the center of the Moon.

The exerts a force with a magnitude of 16,000 newtons on . This force is directed toward the center of mass of the lander.

2. Is *work* a scalar quantity or a vector quantity?

- a. Work is a scalar quantity.
 b. Work is a vector quantity.

3. A 40,000-kilogram passenger train on a level track cruises at a speed of 25.0 meters per second. Superman, disguised as Clark Kent, knows that a bridge is damaged ahead, so he puts on his Superman costume, stands in front of the train, and pushes back on it to stop it. By applying a constant force to the train, Superman stops it in a distance of 65.0 meters.

- A. What was the kinetic energy of the train before Superman pushed on it?

B. How much work did Superman do on the train?

C. Was the amount of work Superman did on the train positive or negative?

a. Positive. b. Negative.

D. Superman pushed on the train in the direction directly opposite the train's velocity. What was the magnitude of the force of Superman's push?

E. When stopping the train, Superman applied a constant force. Was the *power* he applied to the train also constant?

a. Yes. b. No, it increased with time. c. No, it decreased with time.

4. To throw a 0.145-kg baseball which is initially at rest, a pitcher applies a horizontal force of 9.10 newtons over a period of 0.500 seconds.

A. What is the impulse that the pitcher applies to the baseball?

B. What is magnitude of the baseball's final momentum?

5. The nearest binary star system to Earth is Alpha Centauri AB. Its two stars are A, with a mass of $1.1 M_{\odot}$, and B, with a mass of $0.9 M_{\odot}$. (M_{\odot} is the mass of the Sun, about 2×10^{30} kilograms.) The distance between them ranges from 11.2 AU to 35.6 AU. (An AU, or astronomical unit, is the average distance from the Sun to Earth, about 1.50×10^{11} meters.) Suppose that at one moment the distance between stars A and B is 16.0 AU. How many AU from Star A is their center of mass?

6. A pendulum is constructed from a rigid, massless rod of length $L = 0.45$ m with a point mass $m = 0.200$ kg at one end and a frictionless bearing at the other end, allowing it to rotate about a full circle.

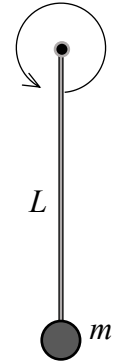
So that everyone's notation is consistent, let's agree that the height y of the point mass is zero at its lowest position (hanging straight down), and that the angle θ describing the rotation of the rod is also zero when the point mass is hanging straight down.

- A. Tell me the formula for the gravitational potential energy of the point mass in terms of y . (y is not necessarily zero.)

- B. Tell me the formula for the gravitational potential energy of the point mass in terms of θ .

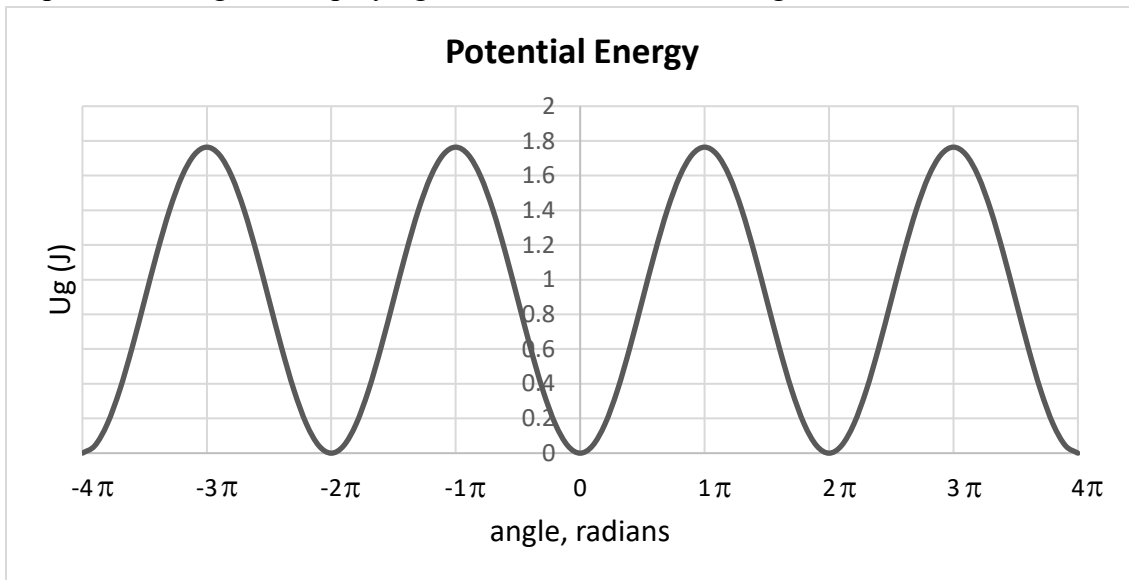
The pendulum is displaced to an angle of $\theta_0 = 50^\circ$, then released from rest so that it swings freely.

- C. (5 points) What is the speed of the point mass when the pendulum passes through the angle $\theta_1 = -20^\circ$?



D. List the forces acting on the point mass in this scenario, and categorize each one as conservative or non-conservative.

Below is a graph of the gravitational potential energy of the point mass as a function of the displacement angle θ , employing our convention that its height is zero at the bottom.



Suppose that the total mechanical energy of the point mass is 1.2 joules and that the pendulum is at an angle of $\pi/3$.

E. What is the approximate gravitational potential energy of the point mass?

F. What is the approximate kinetic energy of the point mass?

G. Describe the motion of the pendulum.

i. What angles can the pendulum reach?

ii. Where is its speed fastest? Slowest?

H. Suppose that the total mechanical energy of the point mass is 2.5 joules and that the pendulum is at an angle of $\pi/3$. Describe the motion of the pendulum.

i. What angles can the pendulum reach?

ii. Where is its speed fastest? Slowest?

7. What sort of quantity is momentum?

a. Momentum is a scalar.

b. Momentum is a vector.

8. The driver of a 1500-kilogram car traveling north on 9th Street at 30 miles per hour doesn't notice that the 1750-kilogram car ahead of it has slowed to 20 miles per hour. The cars collide and lock bumpers. (If you want to convert, 1 mi/h = 0.447 m/s.)

A. What is the momentum of the 1500-kg car before the collision?

B. What is the momentum of the 1750-kg car before the collision?

C. What is the momentum of the 1500-kg car after the collision?

D. What is the momentum of the 1750-kg car after the collision?

E. What type of collision is this?

a. Elastic.

b. Inelastic.

c. Totally inelastic.

F. How does the total kinetic energy of the cars after the collision compare to before the collision?

- a. Same as before. b. Less than before. c. Greater than before.

9. A neutron, mass 1.6749×10^{-27} kilograms, traveling at a speed of 1000 meters per second, collides elastically with a helium nucleus, mass 6.6447×10^{-27} kilograms, initially at rest. After impact, the helium nucleus moves off in the same direction that the neutron approached.

A. After the collision, what is the velocity of the neutron? (Don't forget the direction.)

B. After the collision, what is the velocity of the helium nucleus? (Don't forget the direction.)

C. How does the total kinetic energy of the neutron and helium nucleus after the collision compare to before the collision?

- a. Same as before. b. Less than before. c. Greater than before.

10. The wheels on the bus go 'round and 'round. From an initial angular speed of 12.0 radians per second, they accelerate at a steady rate to a final angular speed of 22.0 radians per second over a time of 10.0 seconds. The wheels have a radius of 0.54 meters.

A. Through how many radians do the wheels rotate as they accelerate?

B. What distance does the bus travel as it accelerates?