GENERAL

central net force model worksheet 1

Published: September 3, 2026 | Index ID: #-

Central Net Force Model Worksheet 1: A Complete Guide for Students and Teachers

When students first encounter the concept of forces acting in a single direction—central forces—they often struggle to see how all the pieces fit together. The **central net force model worksheet 1**is designed to bridge that gap, turning abstract equations into tangible, step by step problems. In this article, we'll walk through the worksheet's structure, explain the underlying physics, and provide practical tips for both teachers and learners. By the end, you'll have a solid understanding of how to approach central force problems and how to use the worksheet as a powerful study tool.

What Are Central Forces?

Central forces are forces that point directly toward or away from a fixed point, called the center. The magnitude of such forces depends only on the distance between the two bodies, never on the direction of motion. Classic examples include:

- Gravitational attraction between planets and the Sun.
- Electrostatic forces between charged particles.
- Magnetic forces in a magnetic mirror used in fusion research.

Because the force vector always points along the line connecting the two bodies, the motion is confined to a plane. This simplifies the analysis, allowing us to use polar coordinates and reduce the problem to a single radial equation.

The Net Force in a Central Force System

In any mechanical system, the **net force**is the vector sum of all individual forces acting on an object. For central force systems, the net force is usually the central force itself, unless additional forces—like friction or thrust—are present. The net force determines the acceleration via Newton's second law:

F_{net} = m·a

Because the direction of the central force is always radial, the acceleration also has a radial component. In a two body system, the relative motion can be described by a single equation for the distance r(t), making the analysis tractable.

Why Worksheets Matter for Mastery

Physics is as much about problem solving as it is about theory. Worksheets provide:

- Structured practice that reinforces key concepts.
- Immediate feedback when solutions are checked.
- Scaffolded difficulty, allowing students to progress from simple to complex scenarios.
- A platform for teachers to assess understanding and identify misconceptions.

The **central net force model worksheet 1**is no exception. It takes the foundational knowledge of central forces

and challenges learners to apply it in a variety of contexts, building confidence and analytical skill.

Overview of Central Net Force Model Worksheet 1

Worksheet 1 is structured into four main sections, each focusing on a different type of central force problem. The problems are ordered by increasing difficulty and complexity:

1. Two body interaction with a simple inverse square law.
2. Gravitational attraction in a planetary system.
3. Electrostatic forces between charged particles.
4. Centripetal force in uniform circular motion.

Each problem includes sub questions that require students to:

- Identify the relevant forces.
- Apply Newton's second law in radial coordinates.
- Solve for unknown variables such as velocity, acceleration, or orbital period.
- Interpret the physical significance of the results.

The worksheet is designed for use in high school physics or introductory college mechanics courses. It assumes familiarity with basic vector algebra, Newtonian dynamics, and the concept of a force field.

Step by Step Guide to Solving Worksheet 1

Problem 1: Two Body Interaction

Scenario: Two masses, m1 = 5 kg and m2 = 3 kg, are connected by a massless string and placed in a vacuum. The only force acting is an attractive central force proportional to 1/r², where r is the distance between the masses. Initially, the masses are 2 m apart and at rest.

Tasks:

1. Write the expression for the central force between the masses.
2. Determine the acceleration of each mass.
3. Find the time it takes for the masses to collide, assuming no other forces act.

Solution:

1. Let k be the force constant. The force magnitude is F = k / r².
2. Newton's second law gives m1a1 = F and m2a2 = F. Since the masses are attracted toward each other, a1 = F / m1 and a2 = F / m2. Because the string is massless, the tension is equal and opposite, so the relative acceleration is arel = a1 + a2 = k(1/m1 + 1/m2) / r².
3. For a simplified estimate, assume the acceleration increases linearly with decreasing r. Integrating the relative acceleration from r = 2 m to r = 0 gives t "H " (r €³ / (2k(1/m1 + 1/m2))). Substituting the values yields a time of roughly 0.5 s (exact value depends on k).

Key Takeaway: In a two body central force system, the relative motion can be treated as a single effective particle with reduced mass ;Â Ò †Ó Ó"' ò †Ó ² Ó"'à

Problem 2: Gravitational Attraction in a Planetary System

Scenario:A satellite of mass 1000 kg orbits Earth at an altitude of 300 km. Earth's mass is 5.97 × 10² t kg. Assume the orbit is circular and neglect atmospheric drag.

Tasks:

1. Calculate the gravitational force between Earth and the satellite.
2. Determine the orbital speed of the satellite.
3. Find the orbital period.

Solution:

1. The distance from Earth’s center is r = 6371 km + 300 km = 6671 km = 6.671 × 10 v m. Gravitational force: F = G·MEarth·m / r² = (6.674 × 10 {¹¹)(5.97 × 10² t)(1000) / (6.671 × 10 v)² "H 7.2 × 10 t N.
2. For circular motion, centripetal force equals gravitational force: m·v² / r = F. Solve for v: v = " (G·MEarth / r) "H 7.67 km/s.
3. Orbital period T = 2< " ò b $, #À(6.671 × 10 v) / 7.67 × 10³ "H 5460 s "H 91 minutes.

Key Takeaway: Circular orbits are a special case of central force motion where the centripetal acceleration is provided entirely by gravity.

Problem 3: Electrostatic Force Between Charged Particles

Scenario: Two point charges, q1 = +2 ;Ä0 and q2 = –3 ;Ä0, are separated by 0.5 m in vacuum. The charges are free to move.

Tasks:

1. Compute the magnitude of the electrostatic force.
2. Determine the acceleration of each charge (assume masses m1 = 1 kg and m2 = 2 kg).
3. Find the time taken for the charges to collide, assuming no other forces act.

Solution:

1. Electrostatic force: F = kE·|q1·q2| / r² = (8.988 × 10 y)(2 × 10 { v)(3 × 10 { v) / (0.5)² "H 0.216 N.
2. Acceleration of q1: a1 = F / m1 = 0.216 / 1 = 0.216 m/s². Acceleration of q2: a2 = F / m2 = 0.216 / 2 = 0.108 m/s².
3. Relative acceleration arel = a1 + a2 = 0.324 m/s². Time to collide: t = " (2r / arel) = " (1 / 0.324) "H 1.75 s.

Key Takeaway: Even with small forces, the resulting accelerations can be significant if the masses are small, demonstrating the importance of mass in dynamics.

Problem 4: Centripetal Force in Uniform Circular Motion

Scenario: A car is traveling around a flat circular track of radius 100 m at a constant speed of 20 m/s.

Tasks:

1. Calculate the centripetal force required to keep the car on the track.
2. Determine the normal force exerted by the track if the car’s mass is 1500 kg.
3. Explain what would happen if the centripetal force were insufficient.

Solution:

1. Fc = m·v² / r = 1500·(20)² / 100 = 6000 N.

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