Georgia Tech Center for Academic Success

PHYS 2211 MODERN READING DAY STUDY SESSION WORKSHEET

Problems

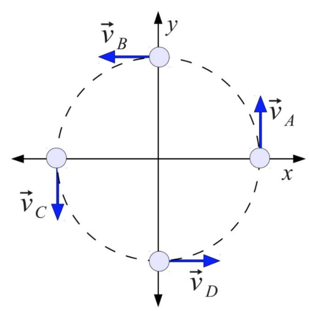
Momentum Principle & Vectors

1. The position of a golf ball relative to the tee changes from $\langle 50, 20, 30\rangle\ m$ to $\langle 53, 18, 31\rangle\ m$ in 0.1 seconds. Determine the unit vector that points in the direction of the average velocity during this short time interval.

2. Standing on Earth, you throw a small rock with a mass of $0.50\,kg$ into the air. At the instant it leaves your hand, the rock's velocity is $\langle 0.1, 4, 0.3\rangle\ m/s$. You may ignore the force of air resistance.
   (a) What is the rock's initial momentum just after it leaves your hand? Express your answer as a vector.
   (b) What is the rock's momentum 0.25 seconds after it leaves your hand? Express your answer as a vector.
   (c) Calculate the average velocity of the rock from just after it leaves your hand to 0.25 seconds later. Express your answer as a vector.
   (d) If the rock's initial position just as it leaves your hand is $\langle 0, 1.2, 0\rangle\ m$, find the vector position of the ball after 0.25 seconds.

3. An electron with a speed of $0.98c$ is emitted by a supernova, where c is the speed of light. The electron is then decelerated by a constant force for 0.25 seconds. After this time the speed of the electron is $0.91c$. What is the magnitude of this force? (Mass of Electron $= 9 \times 10^{-31}\ kg$)

4. The moon circles around the earth in a circular orbit at constant speed.
   (a) What is the direction of the change in momentum of the moon from point B to point D?
   (b) What is the direction of the change in momentum of the moon from point A to point D?



Energy Principle/Thermal Energy & PP v Real System

5. A horizontal spring-mass system has spring stiffness (spring constant) $k_s = 210\,N/m$, and mass $m = 0.4\,kg$. At $t = 0$, the spring is compressed $12\,cm$ from its relaxed length, and the mass has a speed of $3\,m/s$. Assume friction is negligible.
   (a) Draw an Energy versus Time graph and draw the Kinetic Energy, Potential Energy, and Total Energy curves of the system.
   (b) What is the speed of the mass when the spring returns to its relaxed length? Now assume friction isn't negligible and the block will eventually come to rest. The block is observed to come to rest when the spring is at its relaxed length. Determine the change in thermal energy for the block. You can assume there is no transfer of energy Q between the system and surroundings.

6. For each system, draw the kinetic, potential, and total energy curves on an Energy versus Position graph.

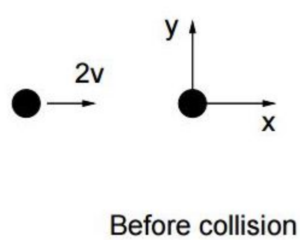
(a) A system of two stars which start out far apart, with one star chasing the other (their initial velocities are nonzero and pointed in the same direction).
(b) A system of a proton and an electron which start out far apart, with the proton chasing the electron (their initial velocities are nonzero and pointed in the same direction).
(c) A system of two protons which start out at some finite distance apart, with one proton chasing the other proton (their initial velocities are nonzero and pointed in the same direction).

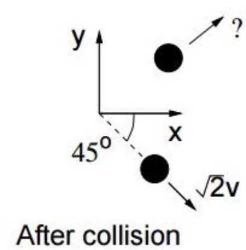
7. You put a thin metal pot containing $2\,kg$ of room temperature ($12°\,C$) water on a hot electric stove. You also stir the water vigorously with an electric beater, which does $100\;J$ of work on the water every second. You observe that after 15 minutes the water reaches a temperature of $100°\,C$. The specific heat capacity of water is $4.2\,J/(g°\,C)$.
(a) What was the change $\Delta E_{thermal}$ in the water?
(b) What was the thermal transfer of energy Q into the water from the surroundings?
(c) What was the change $\Delta E_{surroundings}$?
(d) You take the pot off the stove and drop in $2.26\,kg$ of sweet potatoes. The potatoes are initially room temp ($25°\,C$) and a specific heat capacity of $3.14\,J/(g°\,C)$. Determine the final temp of the water and sweet potatoes once they come to equilibrium. Assume the pot is a very good insulator and doesn't change temp (ignore change in thermal energy of the pot).

Curving Motion & Collisions

8. There is an amusement park ride in which a bunch of people of mass M stand against the wall of a cylindrical room of radius R, and the room starts to rotate at higher and higher speed. The surface of the wall is designed to maximize friction between the person and the wall, so it is sticky, not slick. When a certain critical speed V is reached, the floor drops away, leaving the people stuck against the wall as they whirl around at a constant speed. What is the coefficient of static friction between the people and the wall at this point? (Hint: Draw a FBD for the person against the wall.)

9. A particle of mass m collides with a second particle of mass m. Before the collision the first particle is moving in the x-direction with a speed $2v$ and the second particle is at rest. After the collision, the second particle is moving in the direction $45°$ below the x-axis and with a speed $\sqrt{2}v$.





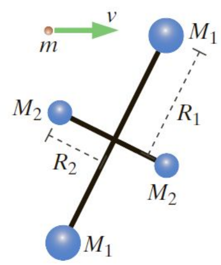
(a) Find the velocity of the first particle after the collision.
(b) Find the total kinetic energy of the two particles before and after the collision.
(c) Is the collision elastic or inelastic?

Angular Momentum Principle/Torque

10. A cockroach with mass m runs counterclockwise around the rim of a lazy susan (a circular dish mounted on a vertical axle) of radius R and rotational inertia I with frictionless bearings. The cockroach's speed (with respect to the earth) is v whereas the lazy susan turns clockwise with angular speed ω_0. The cockroach finds a bread crumb on the rim and, of course, stops. What is the angular speed of the lazy susan after the cockroach stops?

11. A very lightweight circular platform has a weight of $300.0\,N$ placed on it at a distance $25\,cm$ from its center. The platform is placed horizontally on a pedestal such that a frictional drag force acts on the platform at the point where the weight is. The coefficient of friction is $\mu = 0.050$.
    (a) Sketch the forces acting on the platform (assume it has zero mass) and find their numerical values.
    (b) Calculate and sketch all torques acting on the system.
    (c) If the platform initially rotates at $8\pi\, radians/s$, find how long it takes for it to slow down and stop.

12. A device consisting of four heavy balls connected by low-mass rods is free to rotate about an axle. It is initially not spinning. A small bullet traveling very fast buries itself in one of the balls. $m = 0.002\,kg$, $v = 550\,m/s$, $M_1 = 1.2\,kg$, $M_2 = 0.4\,kg$, $R_1 = 0.6\,m$, and $R_2 = 0.2\,m$. The axle of the device is at the origin $\langle 0, 0, 0\rangle$, and the bullet strikes at location $\langle 0.155, 0.580, 0\rangle\,m$. Just after the impact, what is the angular speed of the device? Note that this is an inelastic collision; the system's temperature increases.



Answers

Momentum Principle & Vectors

1. $\hat{v}_{avg} = \langle 0.80, -0.53, 0.27 \rangle$

2. (a) $\overrightarrow{p_i} = \langle 0.05, 2, 0.15 \rangle kgm/s$
   (b) $\overrightarrow{p_f} = \langle 0.05, 0.775, 0.15 \rangle kgm/s$
   (c) $\overrightarrow{v_f} = \langle 0.1, 1.55, 0.3 \rangle m/s$; $\overrightarrow{v}_{avg} = \langle 0.1, 2.775, 0.3 \rangle m/s$
   (d) $\overrightarrow{r_f} = \langle 0.025, 1.894, 0.075 \rangle m$

3. $p_1 = 4.9mc$; $p_2 = 2.19mc$; $|\overrightarrow{F}_{net}| = 2.95 \times 10^{-21}\, N$

4. (a) $\longrightarrow$ (b) $\searrow$

Energy Principle/Thermal Energy & PP v Real System

5. (b) $v_f = 4.07\, m/s$; (c) $\Delta E_{thermal} = 3.312\, J$

6. -
7. (a) $\Delta E = 739200\, J$
   (b) $Q = 649200\, J$
   (c) Negative part of (a)$= -739200\, J$
   (d) $T_f = 65.65°C$

Curving Motion & Collisions

8. $\mu_s \geq \frac{gR}{v^2}$

9. (a) $v_{1x} = v$, $v_{1y} = v$; (b) Before $= 2mv^2$, After $= 2mv^2$; (c) Elastic collision

Angular Momentum Principle/Torque

10. $\omega_r = \frac{L_r}{I_r} = \frac{Rmv + I\omega_0}{I + mR^2}$

11. (b) $3.75\, Nm$ ($-y$ direction); (c) $12.8\, sec$

12. $0.711\, rad/sec$