

CHAPTER 9 PRACTICE PASSAGE

A physics student conducts an experiment to study pendulums and momentum. Using an apparatus known as *Newton's cradle*, the student conducts two different trials. The Newton's cradle apparatus consists of five identical steel balls of equal size and mass. Each ball is suspended from two wires that connect it to a frame, so that the ball is in the air and can move side to side in a single plane. The balls are suspended so that they are touching each other and are free to move individually or as a group. Each ball can be considered a simple pendulum since the hanging wires have negligible mass. Assume there is no friction in the pendulum mechanism.

For the first trial, Ball A is raised at an angle, θ , from the vertical and let go. The ball swings down and hits Ball B. Momentum is transferred through Balls B, C, and D to Ball E, causing Ball E to swing up to a maximum angle, θ , from the vertical on the right while Balls A, B, C, and D are stationary. Then Ball E swings down and hits Ball D, transferring momentum through Balls D, C, and B to Ball A, causing Ball A to swing up again to the same maximum angle, θ , from the vertical while Balls E, D, C, and B are stationary. The period for this motion is measured to be 1.5 seconds.

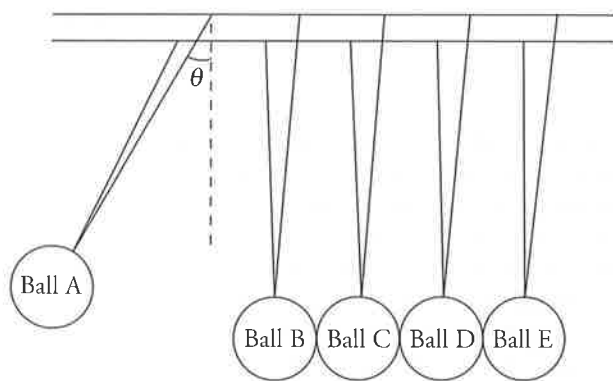


Figure 1 Newton's Cradle Apparatus with Ball A raised at the start of Trial 1

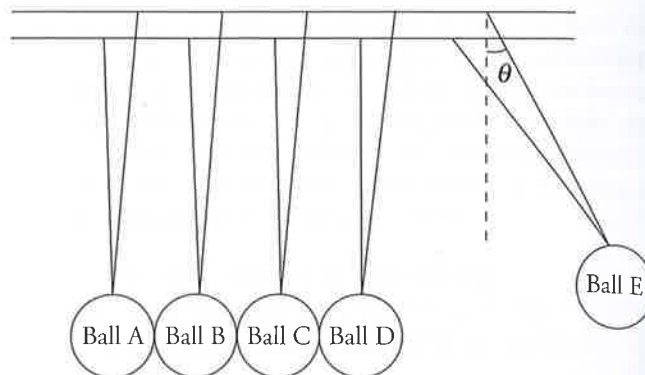


Figure 2 Newton's Cradle Apparatus after transfer of momentum to Ball E during Trial 1

For the second trial, both Ball A and Ball B are lifted together to the same angle, θ , as in the first trial. The result of the swing is that both Ball D and Ball E swing up on the right with the same displacement angle, θ . As in the first trial, momentum is conserved.

- Which of the following is true during the experiment?
 - Kinetic energy is not conserved and the collisions are inelastic.
 - Kinetic energy is not conserved and the collisions are elastic.
 - Kinetic energy is conserved and the collisions are inelastic.
 - Kinetic energy is conserved and the collisions are elastic.
- Which of the following is true when Ball E is at half of its maximum height as measured from its lowest point?
 - The kinetic energy is half of the total mechanical energy.
 - The velocity is half of the maximum velocity of the ball.
 - The time elapsed from the time Ball E started in motion to the time it reached half of its maximum height is half of the period.
 - I only
 - I and III
 - II and III
 - I, II, and III

3. What should be the measured period in Trial 2?

- A) 1.0 seconds
- B) 1.5 seconds
- C) 2.0 seconds
- D) 3.0 seconds

4. For Ball E, how does the maximum velocity in Trial 2, v_2 , compare to the maximum velocity in Trial 1, v_1 ?

- A) $v_2 = (1/2)v_1$
- B) $v_2 = (1/2)v_1$
- C) $v_2 = v_1$
- D) $v_2 = 2v_1$

5. To help record results, the student attached pens of negligible mass to each ball and scrolled paper perpendicular to the axis of motion of the Newton's cradle. The paper scrolls at a rate of 20 cm/s underneath the pens during the trials. What is the wavelength of the resulting wave graphed in Trial 1?

- A) 13 cm
- B) 20 cm
- C) 30 cm
- D) 33 cm

6. If L is the length of each string, what is the maximum height of Ball E in Trial 1 above its lowest position?

- A) $L - \cos \theta$
- B) $L - L \cos \theta$
- C) $L + L \cos \theta$
- D) $L \cos \theta$

7. In both Trial 1 and Trial 2 of the experiment, the number of balls that moved on the right side was the same as the number of balls lifted on the left side to start the motion, while all the central balls remained stationary. Which of the following changes to the experiment would most likely result in not having the same number of balls swing on each side of the apparatus?

- A) Raise three balls on the left side to start the motion.
- B) Increase the length of the wires holding the balls.
- C) Change the masses of the balls so that each mass is different from the others.
- D) Add a small space between each of the balls as they hang on the apparatus.