Seminar 3: Lectures 5-6

Print and answer all questions found below.
Please bring your completed worksheet to the Seminar Class.

Question 1

A spring is attached to a ceiling and a mass $m = 2.0kg$ is hung vertically from it. The spring has a spring constant $k = 100N/m$.

(a) Calculate the extension of the spring due to the hanging mass.

(b) If the spring is pulled down an additional $0.1\ m$ and released, calculate the maximum speed of the mass during the oscillation.

(c) Draw a graph showing the force vs. extension for the spring, indicating the points corresponding to the natural length, stretched length due to the mass, and the maximum stretch.

(d) If the spring was replaced with one having a spring constant of $k' = 200N/m$, how would the extension and maximum speed change?

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Question 2

A 1.5 kg block slides on a frictionless surface and compresses a spring with a spring constant of $250\ N/m$ by $0.2\ m$. Subsequently, we change the nature of the surface, and the block is released, moving along a rough surface with a coefficient of kinetic friction of 0.2 for $0.5\ m$.

(a) Calculate the initial potential energy stored in the spring.

(b) Determine the work done by friction on the block.

(c) Calculate the final velocity of the block after it passes the rough surface.

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Question 3

A 0.5 kg ball moving at 4 m/s collides with a 1 kg ball at rest. After the collision, the 0.5 kg ball moves at 2 m/s at the same direction.

(a) Calculate the velocity of the 1 kg ball after the collision.

(b) Determine the impulse experienced by the 1 kg ball.

(c) Check whether the collision is elastic.

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Question 4

Two carts are on a frictionless track and collide. Cart 1 has a mass of $m_1 = 1.5\ kg$ and is moving to the right with an initial velocity of $v_{1i} = 2.0\ m/s$. Cart 2 has a mass of $m_2 = 2\ kg$ and is moving to the left with an initial velocity of $v_{2i} = -3.0\ m/s$. After the collision, both carts move with unknown velocities v_{1f} and v_{2f}.

(a) Derive the equations for the final velocities v_{1f} and v_{2f} using the principle of conservation of momentum.

(b) Assuming the collision is perfectly elastic, write down the additional equation related to the conservation of kinetic energy, and solve for v_{1f} and v_{2f}.

(c) Calculate the impulse experienced by each cart during the collision.

(d) Draw a diagram showing the initial and final velocities of the two carts before and after the collision.

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Question 5

A car of mass 1500 kg is moving at a constant speed of 20 m/s around a circular track with a radius of 50 m.

(a) Calculate the magnitude of the centripetal force acting on the car.

(b) If the coefficient of friction between the tires and the road is 0.6, determine whether the frictional force is sufficient to keep the car on the circular path without skidding.

(c) If the car were to move at a higher speed of 30 m/s, determine the new centripetal force required.

(d) Explain what would happen to the car if it attempted to go around the curve at this higher speed and the frictional force is the same as in part (b).

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Question 6

A simple pendulum has a length of 2 meters and is displaced to an angle of 15° from the vertical.

(a) Calculate the period of the pendulum.

(b) Determine the maximum speed of the pendulum bob during its motion.

(c) Explain how the period and maximum speed of the pendulum would change if the length of the pendulum were increased. Include diagrams to support your explanation.

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Question 7

Consider a simple pendulum with a bob of mass 0.2 kg that is released from a height of 0.5 m above the lowest point of the swing.

(a) Calculate the potential energy of the pendulum bob at the highest point.

(b) Determine the speed of the bob at the lowest point of the swing.

(c) Describe the motion of the pendulum in terms of kinetic and potential energy conversion. Include a diagram showing the energy transformations.

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Question 8

A 0.150 kg toy is undergoing SHM on the end of a horizontal spring with force constant k=10N/m. When the object is 0.0120 m from its equilibrium position, it is observed to have a speed of 0.3 m/s. Find:

(a) the total energy of the object at any point in its motion,

(b) the amplitude of the motion, and

(c) the maximum speed attained by the object during its motion.

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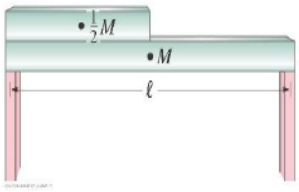
Extension Questions

Question 9

A uniform steel beam has a mass of 940 kg. On it is resting half of an identical beam, as shown in the figure. What is the vertical support force at each end?



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Question 10

A 0.0125 kg bullet strikes a 0.240 kg block attached to a fixed horizontal spring whose spring constant is 2.25×10^3 N$/m$ and sets it into oscillation with an amplitude of 12.4 cm. What was the initial speed of the bullet if the two objects move together after impact?

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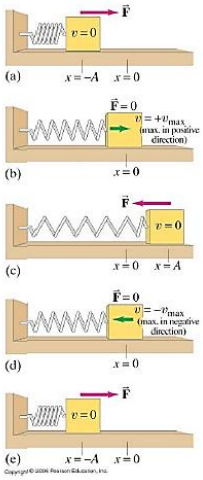
Question 11

Construct a Table indicating the position x of the mass in the figure below at times $t = 0,\ {}^{1}/_{4}\,T, {}^{1}/_{2}\,T, {}^{3}/_{4}\,T \text{ and } {}^{5}/_{4}\,T$, where T is the period of oscillation of the mass spring system seen below.



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