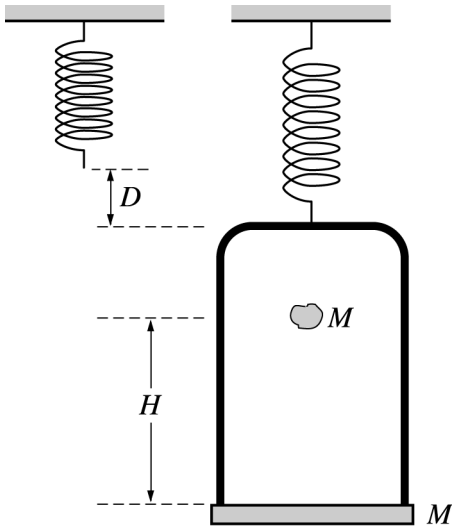

Mech. 2.

An ideal spring is hung from the ceiling and a pan of mass M is suspended from the end of the spring, stretching it a distance D as shown above. A piece of clay, also of mass M, is then dropped from a height H onto the pan and sticks to it. Express all algebraic answers in terms of the given quantities and fundamental constants.

(a) Determine the speed of the clay at the instant it hits the pan.

(b) Determine the speed of the pan just after the clay strikes it.

(c) Determine the period of the simple harmonic motion that ensues.

(d) Determine the distance the spring is stretched (from its initial unstretched length) at the moment the speed of the pan is a maximum. Justify your answer.

(e) The clay is now removed from the pan and the pan is returned to equilibrium at the end of the spring. A rubber ball, also of mass M, is dropped from the same height H onto the pan, and after the collision is caught in midair before hitting anything else.

Indicate below whether the period of the resulting simple harmonic motion of the pan is greater than, less than, or the same as it was in part (c).

_____ Greater than _____ Less than _____ The same as

Justify your answer.

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Question 2

15 points total **Distribution of points**

(a) 2 points

For a statement of conservation of energy 1 point

$MgH = \frac{1}{2}Mv_c^2$

For the correct answer 1 point

$v_c = \sqrt{2gH}$

Alternate solution *Alternate points*

For use of correct kinematics equation $v_c^2 = v_0^2 + 2gH$, *1 point*

OR the combination of $a = g$; $v_c = gt$; and $H = \frac{1}{2}gt^2$,

For the correct answer *1 point*

$v_c = \sqrt{2gH}$

(b) 3 points

For recognition that momentum is conserved in the inelastic collision 1 point

For use of the correct equation expressing conservation of momentum 1 point

$Mv_c = 2Mv_p$

For the correct answer 1 point

$v_p = \frac{1}{2}\sqrt{2gH}$

(c) 4 points

For use of the correct equation for the period of a mass on a spring 1 point

$T = 2\pi\sqrt{\frac{m}{k}}$

For recognition that $m = 2M$ 1 point

For correct calculation of k using the force equation for the initial stretching of the spring 1 point

$Mg = kD$, giving $k = \frac{Mg}{D}$

For the correct answer after substituting for m and k 1 point

$T = 2\pi\sqrt{\frac{2D}{g}}$

Question 2 (cont'd.)

Distribution of points

(d) 3 points

For recognition that the speed v is a maximum at the equilibrium point, which can be correctly described by one or more of the following statements: equilibrium point, $F = 0$, $a = 0$, kinetic energy is a maximum, midpoint of the oscillation, etc. — 1 point

For recognition that there is a new equilibrium point given by the following equation $kx = 2Mg$, where x is the distance the spring is stretched from its initial unstretched length — 1 point

Substituting the value of k found in part (c)

$$\left(\frac{Mg}{D}\right)x = 2Mg$$

For the correct answer

$$x = 2D$$ — 1 point

For a correct answer, $x = 2D$, but with no justification, only 1 point was awarded

(e) 3 points

For a check in the "Less than" space in part (c) — 1 point

For a correct justification that states that in the second case there is less mass oscillating than in part (c) and that the period decreases with decreasing mass, $T = 2\pi\sqrt{\frac{m}{k}}$. — 2 points

(The formula is not necessary for full credit.)