AP® PHYSICS B
2006 SCORING GUIDELINES (Form B)

Question 2

15 points total **Distribution of points**

(a) 4 points

For any use of conservation of energy — 1 point

For example, initially the small block has only potential energy, and it is all converted to kinetic energy when it reaches the bottom of the ramp.

For a correct expression for the initial potential energy — 1 point

For a correct expression for the kinetic energy at the bottom of the ramp — 1 point

$Mgh = \frac{1}{2}M(3.5v_0)^2$

For the correct answer — 1 point

$h = \frac{3.5^2}{2}\frac{v_0^2}{g}$ or equivalent

(b) 4 points

For any use of conservation of momentum — 1 point

For a correct expression for the initial momentum of the blocks — 1 point

For a correct expression for the final momentum of the blocks — 1 point

$M(3.5v_0) = Mv + (1.5M)(2v_0)$

$v = 3.5v_0 - 3v_0$

For the correct answer — 1 point

$v = 0.5v_0$

(c) 4 points

For a correct relationship between friction and the acceleration of the block — 1 point

$\sum F = ma = f_{fric}$

For a correct kinematic equation relating acceleration and distance that does not contain time — 1 point

$v_f^2 = v_i^2 - 2aD$

For using the correct initial speed of the block — 1 point

$0 = 4v_0^2 - 2aD$

$a = 2v_0^2/D$

Substituting expressions for a and f into the first equation above

$(1.5M)2v_0^2/D = \mu(1.5M)g$

For the correct answer — 1 point

$\mu = 2v_0^2/Dg$

Question 2 (continued)

Distribution of points

(c) (continued)

Alternate solution — *Alternate points*

For any indication that the work done on the block as it slides is equal to its initial kinetic energy — *1 point*

$f_{fric}d = \frac{1}{2}mv_i^2$

For a correct expression for the work done on the block — *1 point*

For a correct expression for the initial kinetic energy of the block — *1 point*

$\mu(1.5M)gD = \frac{1}{2}(1.5M)(2v_0)^2$

For the correct answer — *1 point*

$\mu = \frac{2v_0^2}{Dg}$

(d) 3 points

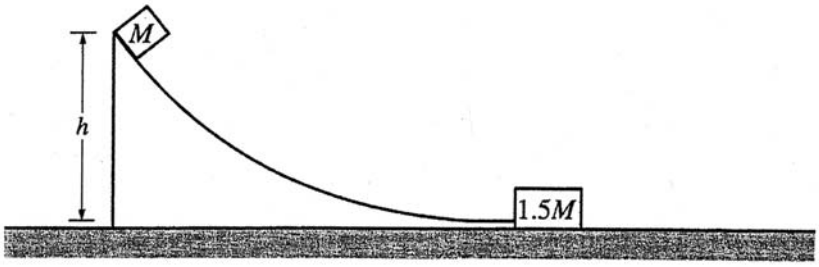
For indicating that the collision is inelastic — 1 point

For indicating that the reason it is inelastic is because the change in kinetic energy is not zero, or because kinetic energy is lost in the collision — 1 point

For showing that the change in kinetic energy is not zero — 1 point

$\Delta K = K_f - K_i = \left[\frac{1}{2}M(0.5v_0)^2 + \frac{1}{2}(1.5M)(2v_0)^2\right] - \frac{1}{2}M(3.5v_0)^2$

$\Delta K = -3Mv_0^2$



2. (15 points)

A small block of mass M is released from rest at the top of the curved frictionless ramp shown above. The block slides down the ramp and is moving with a speed $3.5v_0$ when it collides with a larger block of mass $1.5M$ at rest at the bottom of the incline. The larger block moves to the right at a speed $2v_0$ immediately after the collision. Express your answers to the following questions in terms of the given quantities and fundamental constants.

(a) Determine the height h of the ramp from which the small block was released.

By the conservation of energy:

The decrease in potential energy = The increase in kinetic energy

$$Mgh = \frac{1}{2}MV^2 \Rightarrow Mgh = \frac{1}{2}M(3.5v_0)^2$$

$$\therefore h = \frac{\frac{1}{2}(3.5V_0)^2}{g}$$

$$= \frac{49V_0^2}{8g}$$

(b) Determine the speed of the small block after the collision.

Since there is no external force, the total linear momentum is conserved:

$$M\cdot V_1 + 1.5M\cdot V_2 = M\cdot V_3 + 1.5M\cdot V_4$$

Sub in the value: $V_1 = 3.5V_0$, $V_2 = 0$, $V_4 = 2V_0$

$$3.5MV_0 = 3MV_0 + MV_3$$

$$\therefore V_3 = 0.5V_0$$

$\therefore$ The speed of the small block after the collision is $0.5V_0$

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(c) The larger block slides a distance D before coming to rest. Determine the value of the coefficient of kinetic friction μ between the larger block and the surface on which it slides.

By the conservation of energy.

The decrease in kinetic energy = work done against friction

$$\frac{1}{2}\cdot(1.5M)\cdot(2V_0)^2 = f\cdot D$$

$$f = \frac{3M\cdot V_0^2}{D}$$

The ~~vertical~~ normal force $N = Mg$ as the block is at rest in vertical direction.

$$f = \mu\cdot N = \mu\cdot(1.5Mg)$$

$$\therefore\ \mu = \frac{f}{N} = \frac{3M\cdot V_0^2}{D\cdot 1.5Mg} = \frac{2V_0^2}{Dg}$$

(d) Indicate whether the collision between the two blocks is elastic or inelastic. Justify your answer.

The total kinetic energy before collision:

$$\frac{1}{2}M(3.5V_0)^2 = \frac{49}{8}M\cdot V_0^2$$

The total kinetic energy after collision:

$$\frac{1}{2}M(0.5V_0)^2 + \frac{1}{2}(1.5M)(2V_0)^2 = \frac{25}{8}M\cdot V_0^2$$

$$\frac{49}{8}M\cdot V_0^2 > \frac{25}{8}MV_0^2$$

$\therefore$ there is a loss of energy during the collision.

Hence the collision is inelastic.

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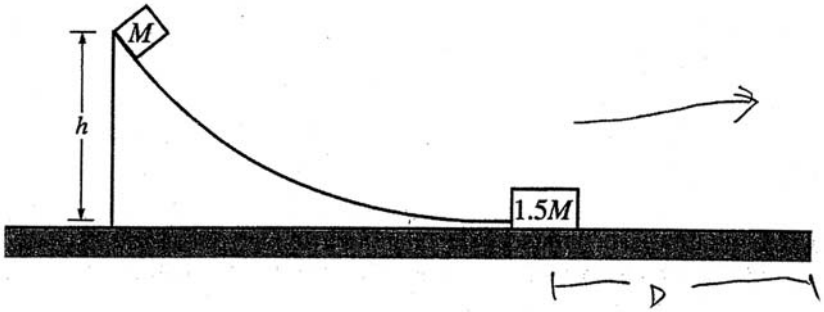

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(a) Determine the height h of the ramp from which the small block was released.

$$Mgh = \frac{1}{2}Mv^2$$

$$5\,10(h) = \frac{1}{2}(3.5v_0)^2$$

$$\boxed{h = \frac{12.25v_0^2}{5}}$$

(b) Determine the speed of the small block after the collision.

$$M_V = M_1V_1 + M_2V_2$$

$$M(3.5v_0) = MV + (1.5M)(2v_0)$$

$$3.5v_0 = V + 3v_0$$

$$\boxed{0.5v_0 = v_f}$$

GO ON TO THE NEXT PAGE.

(c) The larger block slides a distance D before coming to rest. Determine the value of the coefficient of kinetic friction μ between the larger block and the surface on which it slides.

$v_f^2 = v_i^2 + 2ad$ ($v_f = 0$)

$(2v_0)^2 = 2aD$

$a = \frac{2v_0^2}{D}$

$\frac{1}{2}(1.5M)(2v_0)^2 = \frac{1}{2}(1.5M)4v^2$

$= 3Mv^2$ J → Energy

$\Sigma F = ma = F - F_f$

$ma = F - mg\mu$

$\Sigma F = (1.5M)\left(\frac{2v_0^2}{D}\right) = F - (1.5)g\mu_k$

$\mu_k = \frac{F}{g} - \frac{6Mv_0^2}{Dg}$

$\frac{\frac{3Mv_0^2}{D} - F}{1.5g} = -\mu_k$

(d) Indicate whether the collision between the two blocks is elastic or inelastic. Justify your answer.

$KE_1 = \frac{1}{2}mv^2 = \frac{1}{2}M(3.5v_0)^2 = \frac{1}{2}M(12.25v_0^2)$

$= 6.125Mv_0^2$

KE of larger block = $3Mv^2$

KE of smaller block after the collision = $\frac{1}{2}(M)(0.5v_0)^2$

$= \frac{1}{2}(0.25)Mv_0^2$

$= 0.125Mv_0^2$

It is elastic, because the speed of the larger after the collision is $2v_0$ but the speed of the smaller block after the collision is $0.5v_0$. Thus, the two masses do not travel at the same speed after the collision.

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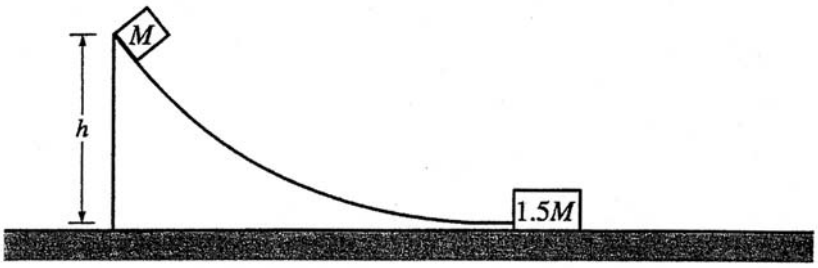

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(a) Determine the height h of the ramp from which the small block was released.

$\frac{1}{2}m_0v_0^2 + m_0g_0h_0 = \frac{1}{2}m_1v_1^2 + mg_1h_1$

$M \times 9.8 \times h = \frac{1}{2}M \times 3.5v_0$

$h = \frac{3.5v_0}{2(9.8)}$

$h = 0.1786v_0$

(b) Determine the speed of the small block after the collision.

$m_0v_0 + m_1v_1 = m_0'v_0' + m_1'v_1'$

$3.5v_0 \times M = Mv_0' + 1.5M \times 2v_1'$

$\frac{3.5v_0}{3v_1'} = v_0'$

$1.167v_0/v_1' = v_0'$

B2C2

(c) The larger block slides a distance D before coming to rest. Determine the value of the coefficient of kinetic friction μ between the larger block and the surface on which it slides.

$F_f = F_n \cdot \mu_K$ $F_n = 1.5 \times 9.8$
$= 14.7N$

(d) Indicate whether the collision between the two blocks is elastic or inelastic. Justify your answer.

elastic collision because as block 1 collides with bigger mass block 2 both blocks has moved along opposite direction to each other.

AP® PHYSICS B
2006 SCORING COMMENTARY (Form B)

Question 2

Sample: B2A
Score: 15

This response is well organized, and the work is very easy to follow. Part (c) uses the alternate solution.

Sample: B2B
Score: 10

Part (a) earned 3 points since the cancellation on the second line is wrong and results in an incorrect answer. Part (b) received full credit. Part (c) earned 2 points for the kinematic equation and use of the correct initial speed. Part (d) earned 1 point for showing that the change in kinetic energy is not zero but does not have a correct conclusion or justification.

Sample: B2C
Score: 4

Part (a) earned 2 points for using conservation of energy and having the correct potential energy. The other 2 points were earned in part (b) for using conservation of momentum and having the correct initial momentum.