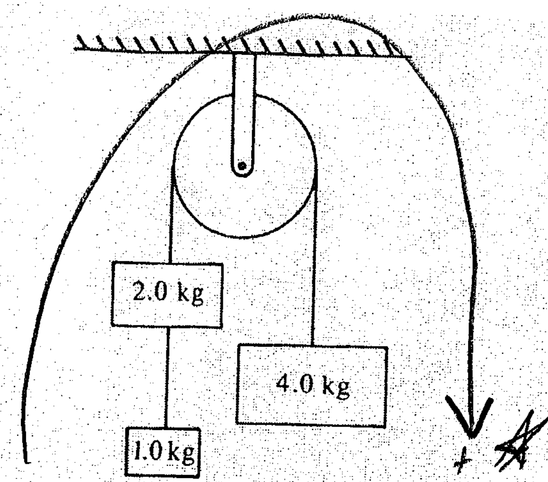
P Physics Part II Midterm Review

Key



1. Three blocks of masses 1.0, 2.0, and 4.0 kilograms are connected by massless strings, one of which passes over a frictionless pulley of negligible mass, as shown above. Calculate each of the following.

   (a) The acceleration of the 4-kilogram block

$a_{4kg} = a_{system}$

$F_{net} = ma$

$$\Sigma F = M_4 g - M_2 g - M_1 g = m_T a$$

$$(4kg)(9.8) - (2kg)(9.8) - (1kg)(9.8) = (4+2+1)a$$

$$39.2 - 19.6 - 9.8 = 7a$$

$$9.8 = 7a$$

$$\boxed{a = 1.4 m/s^2}$$

   (b) The tension in the string supporting the 4-kilogram block

$F_{net} = ma$

$$\Sigma F_4 = M_4 g - T = M_4 a$$

$$(4kg)(9.8) - T = (4kg)(1.4 m/s^2)$$

$$39.2 - T = 5.6$$

$$\boxed{T = 33.6 N}$$

   (c) The tension in the string connected to the 1-kilogram block

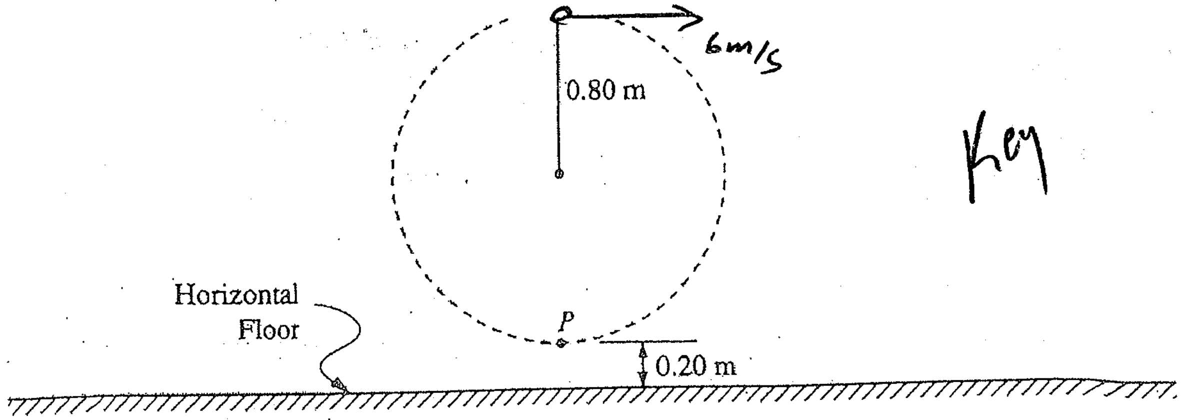
$F_{net} = ma$

$$\Sigma F_1 = T - m_1 g = m_1 a$$

$$T - (1kg)(9.8) = (1kg)(1.4 m/s^2)$$

$$T - 9.8 = 1.4$$

$$\boxed{T = 11.2 N}$$



Key

1. A 0.10-kilogram solid rubber ball is attached to the end of an 0.80-meter length of light thread. The ball is swung in a vertical circle, as shown in the diagram above. Point P, the lowest point of the circle, is 0.20 meter above the floor. The speed of the ball at the top of the circle is 6.0 meters per second, and the total energy of the ball is kept constant.

(a) Determine the total energy of the ball, using the floor as the zero point for gravitational potential energy.

$h = 2(.8) + .2$
$h = 1.6 + .2$
$h = 1.8\text{m}$

$E_T = PE + KE$
$E_T = mgh + \frac{1}{2}mv^2$
$E_T = (.1\text{kg})(9.8)(1.8) + \frac{1}{2}(.1)(6\text{m/s})^2$
$E_T = 1.764 + 1.8 = \boxed{3.564\text{ J}}$

(b) Determine the speed of the ball at point P, the lowest point of the circle.

$h = .2$

$E_T = PE + KE = 3.564$
$mgh + \frac{1}{2}mv^2 = 3.564$
$(.1)(9.8)(.2\text{m}) + \frac{1}{2}(.1)(v)^2 = 3.564$
$.05v^2 = 3.368$

$v^2 = 67.36$
$\boxed{v = 8.2\text{ m/s}}$

(c) Determine the tension in the thread at
i. the top of the circle;

$F_{net} = ma$
$T + mg = \frac{mv^2}{r}$
$T + (.1)(9.8) = \frac{(.1)(6)^2}{.8}$
$\boxed{T = 3.52\text{ N}}$

ii. the bottom of the circle.

$F_{net} = ma$
$T - mg = \frac{mv^2}{r}$
$T - (.1)(9.8) = \frac{(.1)(8.2)^2}{.8}$
$\boxed{T = 9.39\text{ N}}$

The ball only reaches the top of the circle once before the thread breaks when the ball is at the lowest point of the circle.

(d) Determine the horizontal distance that the ball travels before hitting the floor.

X	Y
$V_0 = 8.2$	$V_0 = 0$
$a = 0$	$a = 9.8$
	$d = .2$

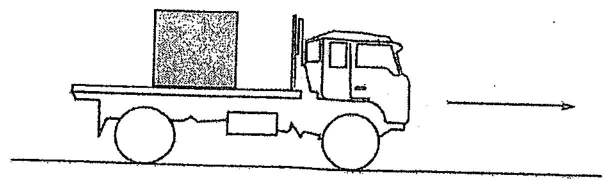
$t = .2\text{sec}$

Y
$d = \cancel{v_0 t}^{0} + \frac{1}{2}at^2$
$.2\text{m} = \frac{1}{2}(9.8)t^2$
$t = .2\text{ sec}$

X
$d = v_0 t + \cancel{\frac{1}{2}at^2}^{0}$
$d = (8.2\text{m/s})(.2\text{sec})$
$\boxed{d = 1.64\text{m}}$

Energy Review with Springs

Key



2. (15 points)

A 4700 kg truck carrying a 900 kg crate is traveling at 25 m/s to the right along a straight, level highway, as shown above. The truck driver then applies the brakes, and as it slows down, the truck travels 55 m in the next 3.0 s. The crate does not slide on the back of the truck.

(a) Calculate the magnitude of the acceleration of the truck, assuming it is constant.

$V_0 = 25$

$d = 55m$

$t = 3 sec$

$a = ?$

$d = V_0 t + \frac{1}{2} a t^2$

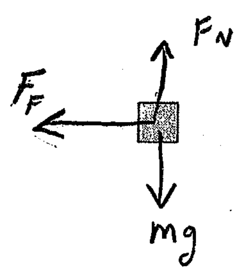
$55m = (25 m/s)(3 sec) + \frac{1}{2}(a)(3)^2$

$55 = 75 + 4.5a$

$-20 = 4.5a$

$\boxed{a = -4.4 \, m/s^2}$

(b) On the diagram below, draw and label all the forces acting on the crate during braking.



(c)

i. Calculate the minimum coefficient of friction between the crate and truck that prevents the crate from sliding.

☆ F_F is the force causing the mass to slow down

$F_{Net} = ma$

$F_{Net} = (900kg)(-4.4)$

$F_{Net} = 3960N$

☆ $F_{Net} = F_F$

only need magnitude

$F_F = \mu F_N$

$F_N = mg$

$3960N = \mu(900kg)(9.8)$

$3960 = \mu(8820$

$\boxed{\mu \approx .45}$

ii. Indicate whether this friction is static or kinetic.

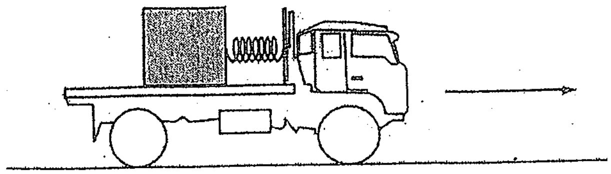
_X_ Static ____Kinetic

(it's Not Sliding)

Continued

Key

Now assume the bed of the truck is frictionless, but there is a spring of spring constant 9200 N/m attaching the crate to the truck, as shown below. The truck is initially at rest.



(d) If the truck and crate have the same acceleration, calculate the extension of the spring as the truck accelerates from rest to 25 m/s in 10 s.

$a = ?$
$V_0 = 0$
$V_f = 25$
$t = 10$
$X = ?$
$F_s = ?$
$K = 9200\ N/m$

$V_f = \cancel{V_0}^{0} + at$

$25 = a(10)$

$a = 2.5\ m/s^2$

$F_{Net} = ma$

$F_{Net} = (900\ kg)(2.5\ m/s^2)$

$F_{Net} = 2250\ N$

$F_s = Kx$

$2250\ N = (9200\ N/m)(x)$

$\boxed{X \approx .24\ m}$

☆ $F_s = F_{Net}$
B/c The spring is applying the force to the block

(e) At some later time, the truck is moving at a constant speed of 25 m/s and the crate is in equilibrium. Indicate whether the extension of the spring is greater than, less than, or the same as in part (d) when the truck was accelerating.

___ Greater   X Less   ___ The same

Explain your reasoning.

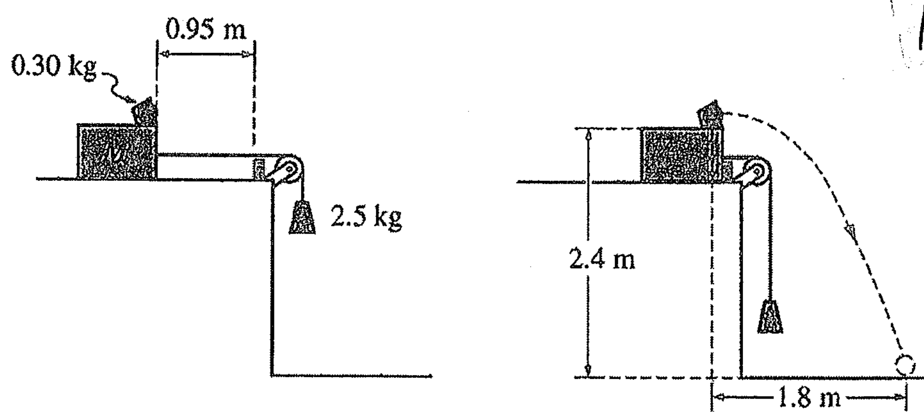
Since it is moving at a constant velocity The Net Force on the block must = zero. This means F_s = zero and "X" must also equal zero.

$F_{Net} = m\cancel{a}^{0}$

$\cancel{F_s}^{0} = K\cancel{X}^{0}$

AP1 Midterm Free Response Review

Key



4. (10 points)

A 0.30 kg ball is in a cup of negligible mass attached to a block of mass M that is on a table. A string passing over a light pulley connects the block to a 2.5 kg object, as shown above. The system is released from rest, the block accelerates to the right, and after moving 0.95 m the block collides with a bumper near the end of the table. The ball continues to move and lands on the floor at a position 2.4 m below and 1.8 m horizontally from where it leaves the cup. Assume all friction is negligible.

(a) Calculate the speed of the ball just after the block hits the bumper and the ball leaves the cup.

X	Y
d = 1.8	d = 2.4
a = 0	a = 9.8
V_0 = ?	V_0 = 0

t = ?

$d_y = \cancel{V_0 t} + \frac{1}{2}at^2$

$2.4\text{m} = \frac{1}{2}(9.8\,\text{m/s}^2)t^2$

$t = .7\text{sec}$

$d_x = V_0 t + \cancel{\frac{1}{2}at^2}$

$1.8\text{m} = V_0(.7\text{sec})$

$\boxed{V_{0x} = 2.57\,\text{m/s}}$

(b) Calculate the magnitude of the acceleration of the block as it moves across the table.

$V_f^2 = \cancel{V_0^2} + 2ad$

$(2.57\,\text{m/s})^2 = 2(a)(.95\text{m})$

$\boxed{a = 3.48\,\text{m/s}^2}$

(c) Calculate the mass M of the block.

$\Sigma F = mg = (M_{Total})a$

$(2.5\text{kg})(9.8) = (2.5\text{kg} + .3\text{kg} + m)(3.48\,\text{m/s}^2)$

$24.5 = (2.8 + m)\,3.48$

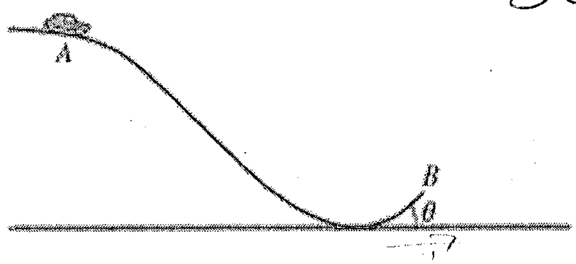
$24.5 = 9.7 + 3.48m$

$\boxed{m = 4.25\text{ kg}}$

(d) If the mass of the ball is increased, the horizontal distance it travels before hitting the floor will decrease. Explain why this will happen.

larger mass will decrease acceleration because the Force is constant $\cancel{F} = ma$. This lower acceleration will cause lower horizontal velocity for the projectile thus decreasing the range

See Typed Sheet on next Page



5. (7 points, suggested time 13 minutes)

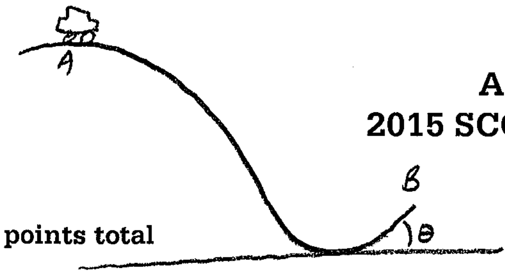
A toy car coasts along the curved track shown above. The car has initial speed v_A when it is at point A at the top of the track, and the car leaves the track at point B with speed v_B at an angle θ above the horizontal. Assume that the rotational kinetic energy of the car's wheels and energy losses due to friction are both negligible.

(a) Suppose the toy car is released from rest at point A $(v_A = 0)$.

i. After the car leaves the track and reaches the highest point in its trajectory it will be at a different height than it was at point A. Briefly explain why this is so.

ii. Determine the speed of the car when it is at the highest point in its trajectory after leaving the track, in terms of v_B and θ. Briefly explain how you arrived at your answer.

(b) Suppose the toy car is given an initial push so that it has nonzero speed at point A. Determine the speed v_A of the car at point A such that the highest point in its trajectory after leaving the track is the same as its height at point A. Express your answer in terms of v_B and θ. Explain how you arrived at your answer.



AP® PHYSICS 1
2015 SCORING GUIDELINES

Key

Question 5

7 points total | **Distribution of points**

(a)

i. 2 points

For indicating that the mechanical energy of the car-Earth system is constant between point A and the highest point in the car's trajectory	1 point
For indicating that the car is still moving at its highest point and has some kinetic energy so the car-Earth system must have less gravitational potential energy, therefore must be at a lower height than it was at point A	1 point

ii. 2 points

For indicating that the velocity of the car at its highest point is equal to the horizontal speed at point B	1 point
For stating that the speed at the highest point is $v_B \cos\theta$	1 point

(b) 3 points

For implicitly or explicitly applying conservation of energy	1 point
For implicitly or explicitly indicating that the gravitational potential energy is the same at the beginning and at the end	1 point
For indicating that the speed is the same at the beginning and at the end, so $v_A = v_B \cos\theta$, or consistent with the answer in part (a-ii)	1 point

© 2015 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

5)

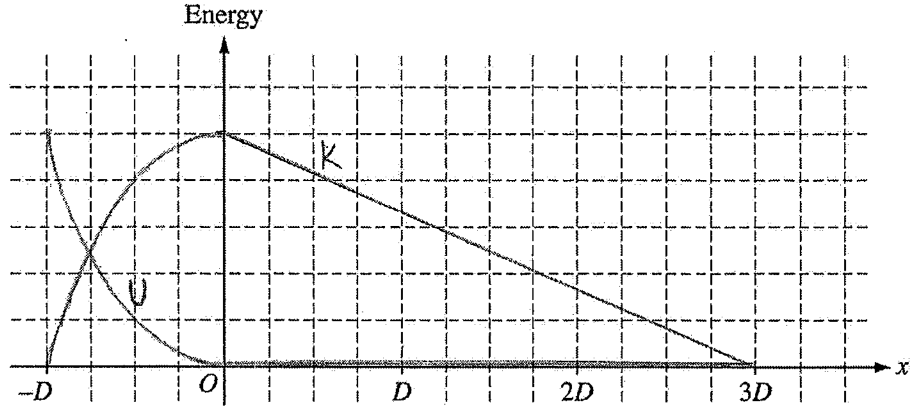
Key

AP® PHYSICS 1
2015 SCORING GUIDELINES

[redacted]

12 points total | **Distribution of points**

(a) 4 points



For sketching either energy curve with a reasonably correct shape between $x = -D$ and $x = 0$, with zero and maximum values at the correct locations — 1 point

For sketching two curves from $x = -D$ to $x = 0$ with shapes and values such that the total energy is constant (even if the curves are incorrect) — 1 point

For sketching potential energy equal to zero from $x = 0$ to $x = 3D$ — 1 point

For sketching kinetic energy as a linear function from its maximum value at $x = 0$ to zero at $x = 3D$ — 1 point

(b)

(i) 1 point

For identifying that the student is correct that the block will have more energy when it leaves the spring — 1 point

(ii) 1 point

For identifying that the student is incorrect about the new final position of the block because the spring's energy does not scale linearly with its compression — 1 point

© 2015 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

Key

5 Continued

[redacted])

Distribution of points

(c) 3 points

For indicating that the final energy in the spring (which becomes the mechanical energy of the block as it reaches the rough track) is four times the original energy in the spring — 1 point

For indicating that the frictional force remains the same — 1 point

For equating the initial energy in the spring to an expression that shows that the energy dissipated by friction is proportional to the distance the block slides down the rough track — 1 point

Example:

$U_1 = \frac{1}{2}kD^2$ and $U_2 = \frac{1}{2}k(2D)^2$ so $U_2 = 4U_1$

$W_1 = \mu mg(3D)$ and $W_2 = \mu mg\Delta x_2$

$W_1 = U_1$ and $W_2 = U_2 = 4U_1 = 4W_1$

$\mu mg\Delta x_2 = 4(\mu mg(3D))$

$\Delta x_2 = 4(3D) = 12D$

(d) 3 points

For indicating that the student's correct reasoning that the block has more energy in the second situation is expressed by the calculations comparing the initial energy in the spring — 1 point

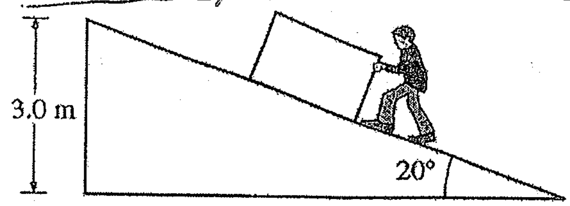
For indicating that the student's correct reasoning that the block will slide farther is expressed by an equation that indicates that the work done by friction to stop the block in the second situation is some factor greater than the work done in the first situation — 1 point

For indicating that the student's incorrect reasoning that energy scales linearly with the spring's compression is corrected by the expression for the initial energy of the spring — 1 point

© 2015 The College Board.
Visit the College Board on the Web: www.collegeboard.org.

AP 1 Free Response Midterm Review

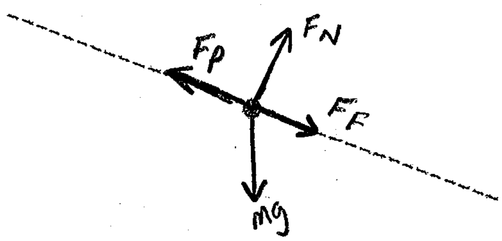
Key



1. (15 points)

A box is being pushed at constant speed up an inclined plane to a vertical height of 3.0 m above the ground, as shown in the figure above. The person exerts a force parallel to the plane. The mass m of the box is 50 kg, and the coefficient of kinetic friction μ_k between the box and the plane is 0.30.

(a) On the dot below that represents the box, draw and label the forces (not components) acting on the box.



(b) Calculate the normal force of the plane on the box. If you need to draw anything other than what you have shown in part (a) to assist in your solution, use the space below. Do NOT add anything to the figure in part (a).

$F_N = mg\cos\theta = (50\,kg)(9.8)\cos 20°$

$\boxed{F_N = 460.4\,N}$

(c) Calculate the component of the force of gravity acting on the box that is parallel to the plane.

$F_{g_{\parallel}} = mg\sin\theta = (50\,kg)(9.8\,m/s^2)(\sin 20°)$

$\boxed{F_{g_{\parallel}} = 167.6\,N}$

(d) Calculate the friction force between the plane and the box.

$F_F = \mu F_N = (.3)(460.4\,N)$

$\boxed{F_F = 138.1\,N}$

(e) Calculate the force applied by the person on the box.

$\Sigma F_{\parallel} = F_p - F_F - F_{g_{\parallel}} = m\cancel{a}^{0}$

$F_p - 138.1\,N - 167.6\,N = 0$

$\boxed{F_p = 305.7\,N}$

(f) Calculate the work done by the person pushing the box, assuming the box is raised to the vertical height of 3.0 m.

$\sin 20° = \frac{3}{d}$

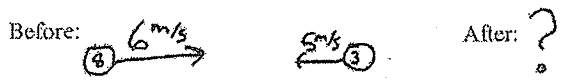
$d = 8.77\,m$

$W = F_{\parallel} d$

$W = (305.7\,N)(8.77\,m)$

$\boxed{W = 2681\,J}$

3) A ball of clay with mass 8 kg slides along a frictionless surface with a speed of 6 m/s. It collides with a 3 kg ball of clay that is sliding towards it at 5 m/s. The two balls of clay stick together and keep sliding.



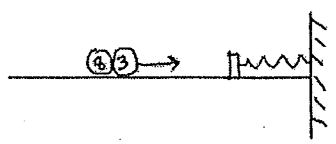
a) What is the final velocity of the combined balls of clay after the collision?

b) How much kinetic energy does the system lose as a result of the collision?

See last Page

c) Give two reasons why kinetic energy was lost in the collision.

The new, larger ball slides along the still-frictionless surface until it hits a spring, which has a spring constant of 600 N/m.

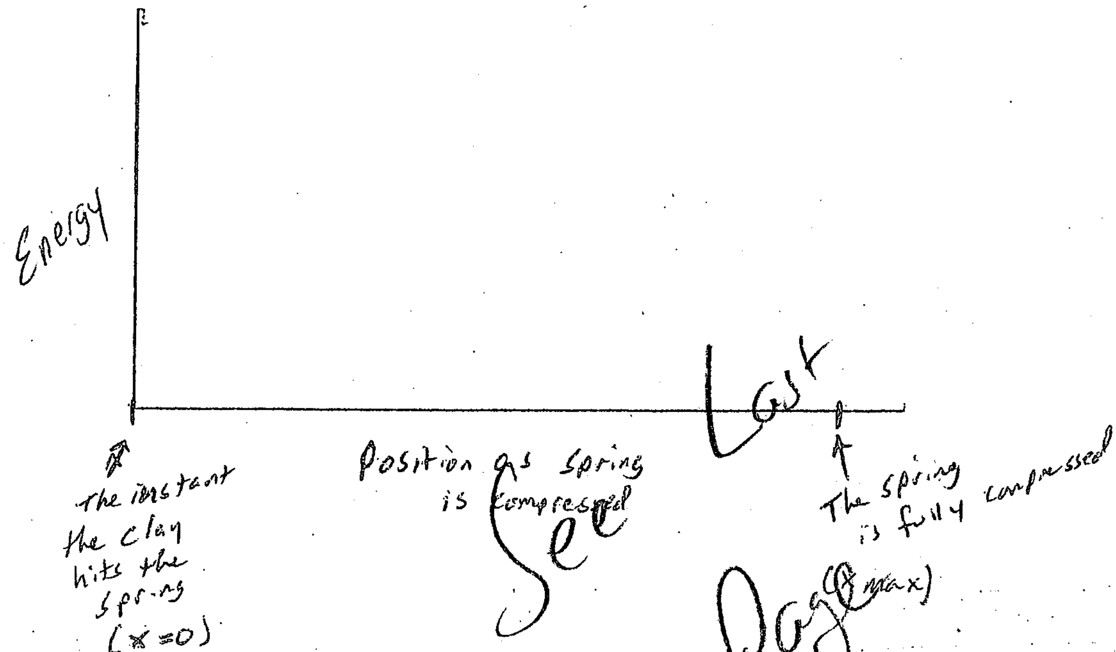


d) How far will the spring be compressed due to the collision?

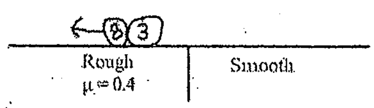
e) What is the maximum force that the spring will apply to the clay?

Continued

f) On the Graph Below draw a dashed line (---) to represent the Kinetic Energy of the ~~block~~ clay from the instant it hits the spring until the spring is fully compressed. On the same axis, draw a solid line (—) to represent the elastic potential energy stored during the same interval (as the spring is compressed.



After rebounding from the spring (with no energy loss), the clay slides off in the opposite direction until it encounters a rough surface. The coefficient of kinetic friction between the clay and surface is 0.4.

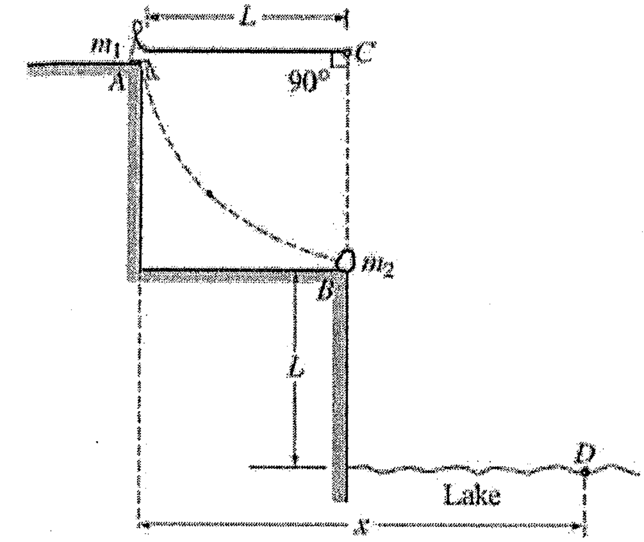


9) How much work must be done by friction in order to stop the clay?

10) How far does the clay slide on the rough surface before stopping?

Key

C2004M1



A rope of length L is attached to a support at point C. A person of mass m_1 sits on a ledge at position A holding the other end of the rope so that it is horizontal and taut, as shown. The person then drops off the ledge and swings down on the rope toward position B on a lower ledge where an object of mass m_2 is at rest. At position B the person grabs hold of the object and simultaneously lets go of the rope. The person and object then land together in the lake at point D, which is a vertical distance L below position B. Air resistance and the mass of the rope are negligible. Derive expressions for each of the following in terms of m_1, m_2, L, and g.

(a) The speed of the person just before the collision with the object

$$E_o = E_f$$

$$PE_A = KE_B$$

$$\cancel{m}gh = \tfrac{1}{2}\cancel{m}v^2$$

$$gL = \tfrac{1}{2}v^2$$

$$v^2 = 2gL$$

$$\boxed{v = \sqrt{2gL}}$$

(b) The tension in the rope just before the collision with the object

$$\Sigma F_y = T - mg = \frac{mv^2}{r}$$

$$T - mg = \frac{m(\sqrt{2gL})^2}{L}$$

$$T - mg = \frac{2mgL}{L}$$

it's ok to leave this

$$T = \frac{2mgL}{L} + mg$$

But it simplifies down to

$$T = 3mg$$

(c) After the person hits and grabs the rock, the speed of the combined masses is determined to be v'. In terms of v' and the given quantities, determine the total horizontal displacement x of the person from position A until the person and object land in the water at point D.

vel

It's a horizontal projectile

X	Y
$V_o = v'$	$d = L$
$a = 0$	$a = g$
	$V_o = 0$

① finding time

Y

$$d = \cancel{V_o t}^{\,0} + \tfrac{1}{2}at^2$$

$$L = \tfrac{1}{2}gt^2$$

$$t = \sqrt{\frac{2L}{g}}$$

② finding horizontal displacement of Projectile

X

$$d = V_o t + \cancel{\tfrac{1}{2}at^2}^{\,0}$$

$$\boxed{d = v'\left(\sqrt{\frac{2L}{g}}\right)}$$

③ Adding to Horizontal distance from pendulum

$$\boxed{d = v'\left(\sqrt{\frac{2L}{g}}\right) + L}$$

Key

3) A ball of clay with mass 8 kg slides along a frictionless surface with a speed of 6 m/s. It collides with a 3 kg ball of clay that is sliding towards it at 5 m/s. The two balls of clay stick together and keep sliding.

Before: 

After: ?

a) What is the final velocity of the combined balls of clay after the collision?

$$p_0 = p_f$$
$$mv + Mv = M_T v$$
$$(8\,kg)(6\,m/s) + (3\,kg)(-5\,m/s) = (8\,kg + 3\,kg)\,v$$
$$48 - 15 = 11v$$
$$\boxed{v = 3\,m/s}$$

b) How much kinetic energy does the system lose as a result of the collision?

$$KE_0 = \tfrac{1}{2}mv^2 + \tfrac{1}{2}mv^2$$
$$= \tfrac{1}{2}(8\,kg)(6\,m/s)^2 + \tfrac{1}{2}(3\,kg)(5\,m/s)^2$$
$$144\,J + 37.5$$
$$KE_0 = 181.5\,J$$

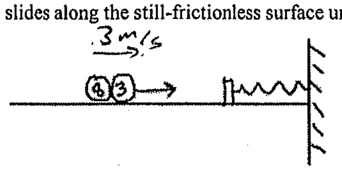
$$KE_f = \tfrac{1}{2}mv^2$$
$$= \tfrac{1}{2}(11\,kg)(3\,m/s)^2$$
$$KE_f = 49.5$$

$$KE_{lost} = KE_0 - KE_f$$
$$= 181.5\,J - 49.5\,J$$
$$\boxed{KE_{lost} = 132\,J}$$

c) Give two reasons why kinetic energy was lost in the collision.

It was Transformed into Heat and Sound energy

The new, larger ball slides along the still-frictionless surface until it hits a spring, which has a spring constant of 600 N/m.



d) How far will the spring be compressed due to the collision?

$$E_0 = E_f$$
$$KE = PE_s$$
$$\tfrac{1}{2}mv^2 = \tfrac{1}{2}kx^2$$
$$\tfrac{1}{2}(11\,kg)(3\,m/s)^2 = \tfrac{1}{2}(600\,N/m)(x^2)$$
$$49.5 = 300x^2$$
$$\boxed{x = .41\,m}$$

e) What is the maximum force that the spring will apply to the clay?

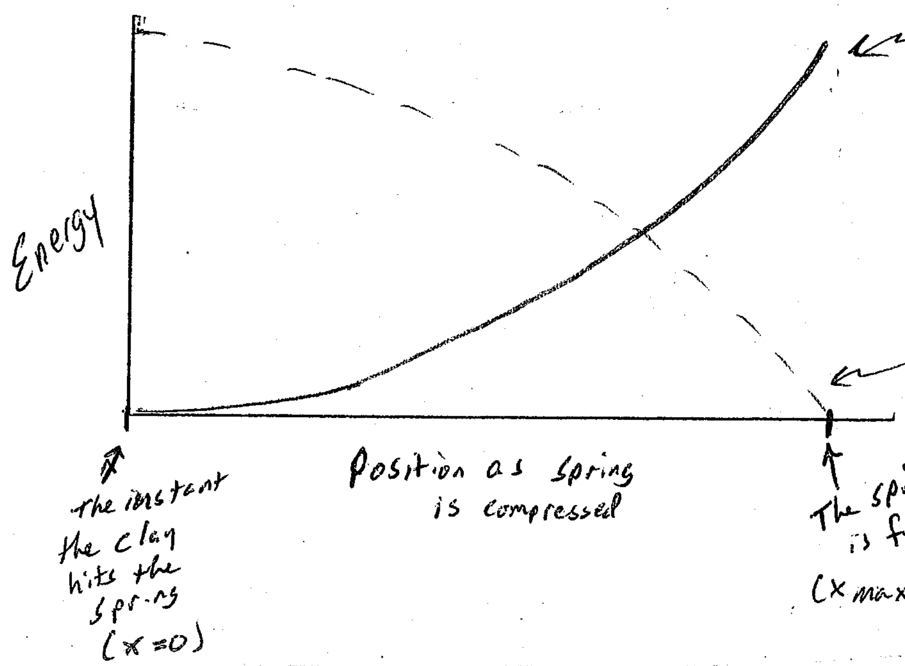
$$F_s = kx$$
$$F_s = (600\,N/m)(.41\,m)$$
$$\boxed{F_s = 246\,N}$$

Continued

3 cont.

Key

f) On the Graph Below draw a dashed line (---) to represent the Kinetic Energy of the ~~block~~ clay from the instant it hits the spring until the spring is fully compressed. On the same axis, draw a solid line (——) to represent the elastic potential energy stored during the same interval (as the spring is compressed

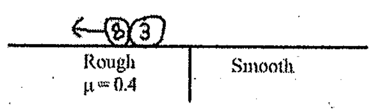


$PE_s = \frac{1}{2}kx^2$

PE is proportional to x^2 so graph should look similar to $y = x^2$

KE will be the mirror opposite because the total energy must always add up to the same number

After rebounding from the spring (with no energy loss), the clay slides off in the opposite direction until it encounters a rough surface. The coefficient of kinetic friction between the clay and surface is 0.4.



g) How much work must be done by friction in order to stop the clay?

$$Work = \Delta KE = KE_f - KE_o$$
$$= 0J - 49.5J$$
$$\boxed{W = -49.5J}$$

h) How far does the clay slide on the rough surface before stopping?

$$W = F_f d$$
$$W = \mu F_N d \qquad F_N = mg$$
$$49.5J = (0.4)(11kg \times 9.8m/s^2)\, d$$
$$\boxed{d = 1.1m}$$