Physics 2210
Fall Semester 2007
David Ailion

1

EXAM 3

Name:________________________ unid: u _ _ _ _ _ _ _

Discussion TA (circle): Aaron Justin [✓ Mahamadou] Monica Will

PLACE A CIRCLE OR BOX AROUND EACH ANSWER!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!

For this problem, very little partial credit will be given. In parts A, B and D, circle the correct answer(s). In part C, write the correct answer in the box.

A. *[5 pts.]* Which of the following is always true in a collision between 2 objects.

(a) Total linear momentum is conserved
(b) Total kinetic energy is conserved.
[✓ (c)] Total energy is conserved.
[✓ (d)] None of the above.

Accept one or the other

B. *[5 pts.]* A skier skis down a smooth frictionless hill with a constant slope.

[✓ (a)] Work done by gravity is positive.
(b) Work done equals change in total energy.
(c) Linear momentum is conserved.
(d) Power is constant.
(e) None of the above.

C. *[5 pts.]* A generator generates energy that can be converted to work at a rate of P = At² + Bt + C, where A = 5.00 J/s², B = −3.00 J/s, C = 12.0 J. Calculate the total energy generated after the first 6.00 seconds of operation.

$$P = At^2 + Bt + C$$

$$E = \int_0^6 P\,dt = \int_0^6 (At^2 + Bt + C)\,dt = \left(\frac{At^3}{3} + \frac{Bt^2}{2} + Ct\right)\Big|_0^6 = \frac{5(6)^3}{3} - \frac{3(6)^2}{2} + 12(6)$$

$$= 360 - 54 + 72 = 378\ J$$

$\boxed{378\ J}$

D *[5 pts.]* A billiard player shoots a ball into another ball which has equal mass and is initially at rest. The surface of the table is frictionless. Which of the following is true after the collision.

(a) The two balls move in the same direction.
(b) The two balls move in opposite directions.
(c) The center of mass is stationary.
(d) The center of mass moves with the same velocity as the original ball.
[✓ (e)] None of the above.

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Name: Solution.

unid: u _ _ _ _ _ _ _

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SHOW ALL WORK !!!
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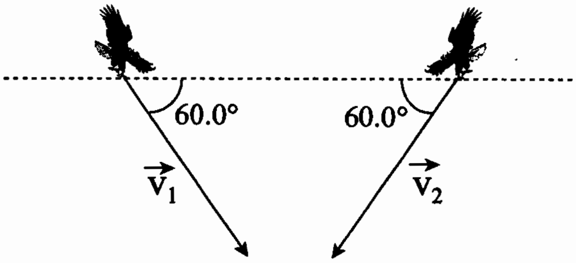
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES

Two birds of prey hurtling after the same mouse, collide mid-air and grasp each others talons. Before the collision, each 250.0 g bird was flying at 30.0 m/s at a 60.0° angle to the ground. See drawing.



(a) *[8 pts.]* What is the magnitude of their velocity immediately after the collision?

(b) *[6 pts.]* What is the horizontal component of their momentum immediately after the collision?

(c) *[6 pts.]* How much, if any, kinetic energy was lost in the collision?

a) conservation of momentum, kinetic energy is not conserved. this is a inelastic collision.

① $\boxed{\hat{x}: m_1 V_{10} \cos\theta - m_2 V_{20} \cos\theta = 0}$

② & $\boxed{\hat{y}: m_1 V_{10} \sin\theta + m_2 V_{20} \sin\theta = (m_1+m_2) V_f}$

$$V_f = \frac{m_1 V_{10} \sin\theta + m_2 V_{20} \sin\theta}{m_1 + m_2}$$

most of you had the equation to the left w/o the sinθ. remember we are conserving momentum in the x and y directions.

$m_1 = m_2$ & $V_{10} = V_{20}$ so

ⓐ

$V_f = V_0 \sin\theta = 30 \sin(60°) = \boxed{26.0 \text{ m/sec}}$

ⓑ as you can see from ① if $m_1 = m_2$ and $V_{10} = V_{20}$ then they just cancel and P_{xf} is zero. $\boxed{\vec{P}_{xf} = 0}$

ⓒ inelastic collision, so kinetic energy was lost $\Delta KE = E_{Loss}$

$KE_0 = \frac{1}{2} m_1 V_{10}^2 + \frac{1}{2} m_2 V_{20}^2 = m V_0^2$ (if $m_1 = m_2$ & $V_{10} = V_{20}$) &

$KE_f = \frac{1}{2} (m_1 + m_2) V_f^2 = m V_f^2$ $m V_f^2 - m V_0^2 = \boxed{-56 \text{ J}}$ Loss.

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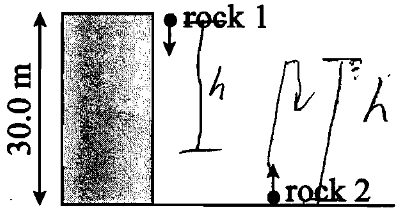
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES

Rock 1 (mass = 4.00 kg) is dropped from the top of a building 30.0 m high. Simultaneously, rock 2 (mass = 3.25 kg) is projected upward with a velocity, v_o = 20.0 m/s. Assume that rock 2 is not directly below rock 1, so they <u>do not</u> collide in mid-air.



(a) *[10 pts.]* Calculate the distance above ground of the center of mass of the system at the moment rock 2 reaches its maximum height.

(b) *[10 pts.]* Calculate the velocity (with sign) of the center of mass at the instant rock 1 hits the ground.

a.) Find h,

$h = \frac{1}{2} g t^2$ or use $\cancel{m_2} g h = \frac{1}{2} \cancel{m_2} v_0^2$

$0 = v_0 - g t$ $\cancel{v_0}$ $h = \frac{v_0^2}{2g} = 20.408$

Rock <u>1</u> will have fallen a distance h as well.

Now,

$$r_{CM} = \frac{m_1 (30.0m - h) + m_2 (h)}{m_1 + m_2} = \boxed{14.4m}$$

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b.) Two ways, can use $V_{cm}(t) = V_{cm}(0) + a_{cm} t$

$$V_{cm}(0) = \frac{(20\,m/s)(3.25\,kg)}{(3.25\,kg + 4\,kg)} = 8.9655\,m/s$$

$$a_{cm} = \frac{-9.8(3.25\,kg) + -9.8(4\,kg)}{3.25\,kg + 4\,kg} = -9.8\,m/s^2$$

$\frac{1}{2} g t^2 = 30m$

$t = \left(\frac{60}{g}\right)^{1/2}$, so $V_{cm}(t) = 8.9655\,m/s - 9.8\,m/s^2 \left(\frac{60}{g}\right)^{1/2}$

$= \boxed{-15.3\,m/s}$

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b.) Or can find individual velocities

$\frac{1}{2} \cancel{m_1} v_1^2 = \cancel{m_1} g (30m) \rightarrow v_1 = -24.2487\,m/s$

$t = \left(\frac{60}{g}\right)^{1/2}$

$v_2 = 20\,m/s - 9.8\left(\frac{60}{g}\right)^{1/2}$ then $V_{CM} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$

$v_2 = -4.2487\,m/s$ $= \boxed{-15.3\,m/s}$

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SHOW ALL WORK !!!
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REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES

You are on a vacation in New Zealand and decide to attempt bungee jumping above a river. Your ankles are joined by a flexible cord to a platform 134.0 m above the river. You jump off the platform. After you have fallen 40.0 m, the bungee cord attached to your ankles starts to stretch. You continue to descend another 80.0 m before coming to rest. Assume that your mass is 100 kg and the cord has negligible mass.

(a) *[10 pts.]* Find the spring constant k of the bungee cord.
(b) *[10 pts.]* Calculate the acceleration at the lowest point (magnitude and direction).

(a) All the forces are conservative here so $E_i = E_f$. If we call the lowest point the ~~to~~ jumper goes to $h=0$ then

$mgh = \frac{1}{2}kx^2$; where $h = 120$ m and $x = 80$m

$$k = \frac{2mgh}{x^2} = \frac{2(100kg)(9.81\,m/s^2)(120m)}{(80m)^2} = 36.75\ N/m$$

b) ~~a~~ Use forces $\Sigma F = ma \Rightarrow kx - gm = ma$

$$a = \frac{kx - mg}{m} = \frac{k}{m}x - g = \frac{(36.75\,N/m)(80m)}{(100\,kg)} - 9.81\,m/s^2)$$

$= 19.6\ m/s^2$

~~us~~ (upward)

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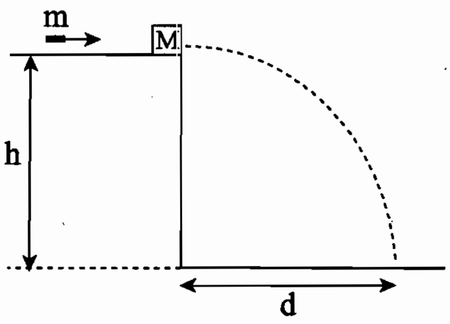
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES

[20 pts.] A bullet of mass m is fired into a block of mass M which is initially at rest at the top edge of a frictionless table of height h. The bullet gets embedded in the block and the block then lands a distance d from the table. Calculate the speed of the bullet just before impact with the block.



conservation of momentum for perfectly inelastic

$$\boxed{m_b V_b = (m_b + M) V}$$

Energy is not conserved in the collision

use kinematics to find V in terms of d, g, h

There are a few ways, but a quick one is $y = y_0 + V_{oy} t + \frac{1}{2} a_y t^2 \Rightarrow \boxed{-h = -\frac{1}{2} g t^2} \Rightarrow \boxed{t = \sqrt{\frac{2h}{g}}}$

then $x = x_0 + V_{ox} t + \frac{1}{2} a_x t^2 \Rightarrow \boxed{d = V_{ox} t} = \boxed{V_{ox} \sqrt{\frac{2h}{g}} = d}$

V_{ox} is constant over the trajectory, at the top and bottom, so $\boxed{V_{ox} = V = \sqrt{\frac{g}{2h}}\, d} \Rightarrow \boxed{V_b = \frac{m_b + M}{m_b} \sqrt{\frac{g}{2h}}\, d}$