PHYS 211 F 2013 11AM Test #2 Name: KEY

$v = v_0 + at$	$x - x_0 = \frac{1}{2}(v + v_0)t$	$v^2 = v_0^2 + 2a(x - x_0)$	$x - x_0 = v_0 t + \frac{1}{2}at^2$	$x - x_0 = vt - \frac{1}{2}at^2$

1. A student writes Newton's second law as, F = ma, which has some errors. Write down Newton's second law without any errors.

$\vec{F}_{net} = m\vec{a}$

2. The high-speed winds around a tornado can drive projectiles into trees, building walls, and even metal traffic signs. In a laboratory simulation, a standard wood toothpick was shot by pneumatic gun into an oak branch. The toothpick's mass was 0.13 g, its speed before entering the branch was 220 m/s, and its penetration depth was 15 mm. If its speed was decreased at a uniform rate, what was the magnitude of the force of the branch on the toothpick?

→ Kinematics: $V_0 = 220$ m/s, $V = 0$, $\Delta x = 15$ mm $= 0.015$ m

need to find the decelleration.

$V^2 = V_0^2 + 2a\,\Delta x$

$0 = 220^2 + 2 \cdot a \cdot (0.015)$

$2 \cdot a \cdot (0.015) = -220^2$

$a = \frac{-220^2}{2 \times 0.015} = -1.61 \times 10^6$ m/s²

$\vec{F} = m\vec{a} = 0.13 \times 10^{-3} \times 1.6 \times 10^6$

$\boxed{\vec{F} = 210\ N}$

3. A 52 kg circus performer is to slide down a rope that will break if the tension exceeds 425 N.
(a) What happens if the performer hangs stationary on the rope? ($g = 9.8$ m/s^2)
(b) At what magnitude of acceleration does the performer just avoid breaking the rope? (Start with a free-body-diagram)

(a)

$T = mg$

$T = 52 \times 9.8$

$= 510\ N > 425\ N$

Rope will break.

(b)

Applying newton's 2nd law:

$\downarrow \vec{F}_{net} = m\vec{a}$

$mg - T = ma$

$\frac{mg - T}{m} = a$

$\frac{52 \times 9.8 - 425}{52} = a$

$\boxed{1.63\ m/s^2 = a}$

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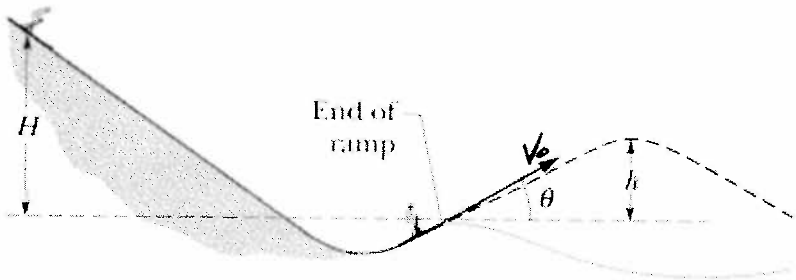
Kinetic energy: $K = \frac{1}{2}mv^2$ Gravitational Potential energy = $U(y) = mgy$

4. A 60 kg skier starts from rest at height $H = 25$m above the end of a ski-jump ramp as shown below and leaves the ramp at angle $\theta = 30°$. Neglect the effects of air resistance and assume the ramp is frictionless.



(a) Use conservation of energy and determine the speed of the skier at the end of ramp.

KE at the end of ramp = PE at the top

$\frac{1}{2}mv^2 = mgH$

$v^2 = 2gH \rightarrow v = \sqrt{2gH} = \sqrt{2 \times 9.8 \times 25} = 22.1$ m/s

$\boxed{V_0 = 22.1 \text{ m/s}}$

(b) What is the maximum height h of his jump above the end of the ramp?

$V_{oy} = V_0 \sin\theta = 22.1 \sin 30° = 11.05$ m/s

$V_y = 0$

$a_y = -9.8$ m/s²

$V_y^2 = V_{oy}^2 + 2a_y h$

$0 = 11.05^2 - 2 \times 9.8 \times h$

$h = \frac{11.05^2}{2 \times 9.8}$

$\boxed{h = 6.23\text{m}}$

(c) What is his speed at the maximum height h of his jump?

$V_y = 0$, $V_{ox} = V_0 \cos 30° = 22.1 \cos 30° = 19.1$ m/s

(d) Starting from the end of ramp, how long it takes to reach the maximum height h of his jump?

$t = ?$ $V_y = V_{oy} + at$

$0 = 11.05 - 9.8t \rightarrow t = \frac{11.05}{9.8} = 1.13$s

(e) Predict how the above answers will change in the presence of friction and air-drag?

Decrease.

5. Momentum, Conservation of Momentum, and Conservation of Energy:

1. Define momentum, identify it as a vector or scalar, and state its SI unit.

momentum = mass × velocity; Vector, $kg \cdot m/s$

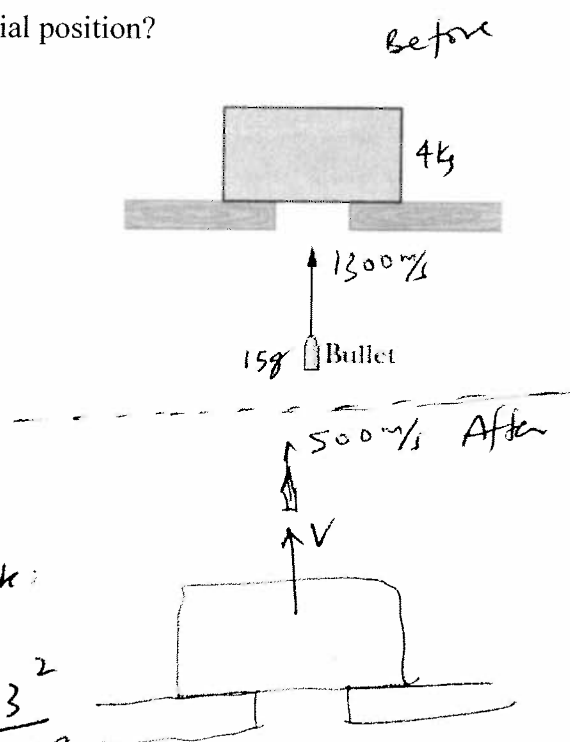
2. State the law of conservation of momentum.

In a ~~closed~~ isolated system the total momentum is conserved.

3. State the law of conservation of energy.

Total energy in a closed system is conserved.

3. In the figure here, a 15 g bullet moving directly upward at 1300 m/s strikes and passes through the center of mass of a 4.0 kg block initially at rest. The bullet emerges from the block moving directly upward at 500 m/s.
a. Identify this collision. Is it elastic, inelastic, or completely inelastic?
b. Using the conservation of momentum, find the speed of the block, just after the bullet emerges.
b. To what maximum height does the block then rise above its initial position?



a. inelastic;

b. Conservation of momentum:

$$0.015 \times 1300 = 0.015 \times 500 + 4V$$

$$19.5 = 7.5 + 4V$$

$$12 = 4V$$

$$\boxed{3\ m/s = V}$$

c. Conservation of energy for the block:

$$\frac{1}{2} m v^2 = mgh$$

$$v^2 = 2gh \longrightarrow h = \frac{v^2}{2g} = \frac{3^2}{2 \times 9.8}$$

$$\boxed{h = 0.46\ m}$$

Impulse: $J = \int F(t)dt = F_{avg}\Delta t = mv_f - mv_i$

6. A soccer player kicks a soccer ball of mass 0.5 kg that is initially at rest. The player's foot is in contact with the ball for 3 x 10^{-3} s, and the force of the kick is given by
$F(t) = [(6 \times 10^6)t - (2 \times 10^9)t^2]$ N, for $0 \le t \le 3 \times 10^{-3}$s, where t is in seconds.
Find the magnitudes of the following: **(a)** the impulse on the ball due to the kick, **(b)** the average force on the ball from the player's foot during the period of contact, **(c)** the maximum force on the ball from the player's foot during the period of contact, and **(d)** the ball's speed immediately after it loses contact with the player's foot.

a) $J = \int F(t)\,dt = \int \left(6\times10^{6} t - 2\times10^{9} t^{2}\right) dt$

$J = \left[6\times10^{6}\frac{t^2}{2} - 2\times10^{9}\frac{t^3}{3} \right]_0^{3\times10^{-3}}$

$J = 3\times10^{6} \times 9\times10^{-6} - 2/3 \times 10^{9} \times 10^{-9} \times 27$

$J = 27 - 18 = \boxed{9\ kg\cdot m/s = J}$

(b) $J = F_{avg}\,\Delta t \rightarrow F_{avg} = J/t = \frac{9}{3\times10^{-3}} = 3000N$

$\boxed{F_{avg} = 3000N}$

(c) $F(t) = 6\times10^{6} t - 2\times10^{9} t^{2}$

$\frac{dF(t)}{dt} = 6\times10^{6} - 4\times10^{9} t = 0$

$t = \frac{6\times10^{6}}{4\times10^{9}} = 1.5\times10^{-3} s = 0.0155$

$F(.0155) = 6\times10^{6} \times 1.5\times10^{-3} - 2\times10^{9} \times (1.5\times10^{-3})^{2}$

$= 9000 - 4500 = 4500N$

$\boxed{F_{max} = 4500N}$

(d) $J = m\vec{v}_f - m\vec{v}_i$

$9 = 0.5\,V_f - 0$

$\boxed{V_f = \frac{9}{0.5} = 18 m/s}$