Physics 105
Test 2A, Sp 20

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Directions: Use $g = 9.80\ m/s^2$ and assume all numbers are accurate to 3 significant figures unless otherwise indicated.
Part A: Select the best answer for five of the following 6 questions/problems. Line out the one that is *not* to be graded. (4 points each)

1. Two identical 7 kg bowling balls roll toward each other. Ball A, on the left, is moving at +4 m/s while ball B, on the right, is moving at -3 m/s. What is the velocity of ball A and ball B after the collision if they collide elastically.
   a. Neither is moving.
   b. -4 m/s, +3 m/s
   c. -1 m/s, +2 m/s
   d. -3 m/s, +4 m/s

2. A moderate force will break an egg. However, an egg dropped on the road usually breaks, while one dropped on the grass usually doesn't break. This is because for the egg dropped on the grass:

   a. the change in momentum is greater.
   b. the change in momentum is less.
   c. the time interval for stopping is greater.
   d. the time interval for stopping is less.

3. A model rocket sits on the launch pad until its fuel is ignited, blasting the rocket upward. During the short time of blast-off, as the ignited fuel goes down, the rocket goes up because:

   a. momentum is conserved in this process.
   b. the fuel pushes on the ground.
   c. air friction pushes on the escaping fuel.
   d. the downward force of gravity is less than the downward momentum of the fuel.

4. If both the mass and the velocity of a ball are tripled, its kinetic energy is increased by a factor of:

   a. 3
   b. 6
   c. 9
   d. 27

~~5. Two~~ rods made of the same material are pulled on each end with the same forces. Rod A has length L and area A, rod B has length 2L and area ½A. If rod A stretches by ΔL, the rod B will stretch by

   a. 4ΔL
   b. 2ΔL
   c. ΔL y
   d. ½ ΔL
   e. ¼ ΔL

Rod A $\frac{F}{A} = Y \frac{\Delta L}{L} \rightarrow \Delta L = \frac{FL}{AY}$

Rod B $\frac{F}{\frac{1}{2}A} = Y \frac{\Delta L}{2L}$

$\Delta L = \frac{F2L}{Y\frac{1}{2}A} \longrightarrow \Delta L = \frac{4FL}{YA}$

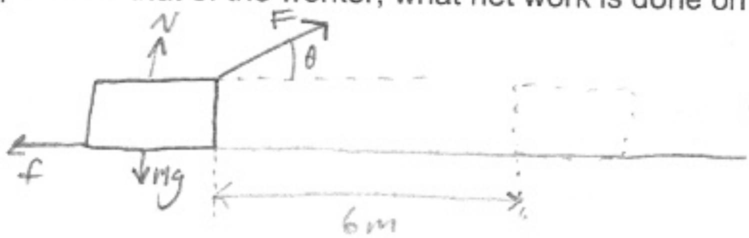
$4\Delta L = \frac{FL}{YA}$

6. As an object is lowered into a deep hole in the surface of the earth, which of the following must be assumed in regard to its potential energy?

   a. increase
   b. decrease
   c. remain constant
   d. cannot tell from the information given

Part B: Answer any five of the following 6 questions/problems and show all work. Line out the one that is *not* to be graded. Incorrect answers supported with work that is substantially correct may receive half credit. No credit will be given for answers without any work or answers that are unsupported by the work displayed. Work that is illegible, illogical, or un-clear may not receive credit. (11 pts each)

7. A worker pulls a sled with a force of 80 N directed at an angle of 60° above the horizontal over a level distance of 6 m. If a frictional force of 24 N acts on the sled in a direction opposite to that of the worker, what net work is done on the sled?



a. 240 J
b. 216 J
c. 156 J
d. 96 J
e. 24 J

$F = 80\,N$
$f = 24\,N$
$\theta = 60°$

$\Sigma F = ma$

$80\cos 60° - 24 = 0$

$W = (80\cos 60° - 24)N\,(6m)\cos 0°$

$\boxed{= 96\,J}$

8. A box of mass 1 kg is placed on a vertical spring (k = 1000 N/m) and pushed down so that the spring is compressed by 0.2 m from the unstretched length. When the spring is released, what is the maximum height above the initial position (when the spring is compressed) the box rises?

$W_{nc} = \Delta P_E + \Delta K_E$
$= K_{Ef} - K_{Ei} + P_{Ei} - P_{Ef}$

a. 2.04 m
b. 8.16 m
c. 1.09 m
d. 0.280 m
e. 0.124 m

+

$K = 1000\ N/m$

$P_{Ei} + K_{Ei} = P_{Ef} + K_{Ef}$

$mgh_i + \frac{1}{2}kx^2 = mgh_f + \frac{1}{2}kx_f^2$

$h_f = \dfrac{\frac{1}{2}kx^2}{mg}$

$= \dfrac{\frac{1}{2}(1000)(.2)^2}{1(9.8)}$

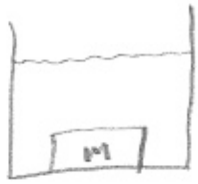
$\boxed{= 2.04\,m}$

$F = kx$

$F = 1000\ N/m\,(.2\,m)$

$F_s = 200\,N$

9. A piece of aluminum has density 2.7 gm/cm³ and mass 775 g. The aluminum is submerged in a container of oil (oil's density = 0.65 gm/cm³). How much oil does the metal displace?



$m = 775 g$

$\rho_{oil} = 0.65 g/cm^3$

$\rho_{alum} = 2.7 g/cm^3$

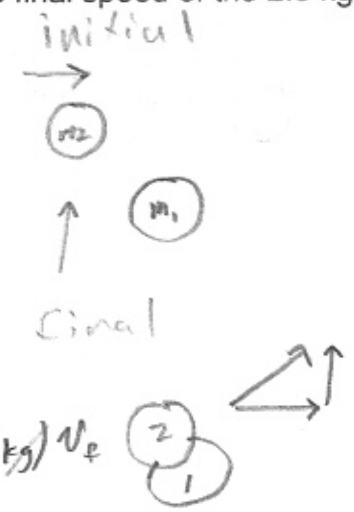
a. 287 cm³
b. 309 cm³
c. 232 cm³
d. 1125 cm³
e. 682 cm³

$$\rho_{alum} = \frac{m_{alum}}{V_{alum}}$$

$$V_{alum} = \frac{m_{alum}}{\rho_{alum}}$$

$$V_{alum} = \frac{775 \cancel{g}}{2.7 \cancel{g}/cm^3} = 287 cm^3$$

10. During a snowball fight two balls, a 1.6 kg ball with a velocity of 10 m/s to the north and a 0.4 kg ball with a velocity of 10 m/s east, collide and combine to form a single mass. What is the final speed of the 2.0 kg mass immediately after collision?



$m_1 = 1.6 kg$

$m_2 = 0.4 kg$

$V_{10} = 10 m/s$

$V_{20} = 10 m/s$

a. zero
b. 3.27 m/s
c. 8.25 m/s
d. 12.4 m/s
e. 13.7 m/s

$\boxed{x}$

$$m_1 \cancel{V_{10x}}^{0} + m_2 V_{20x} = (m_1 + m_2) V_{fx}$$

$$(.4 kg)(10 m/s) = (1.6 + .4 kg) V_f$$

$$4 m/s = 2 V_{fx}$$

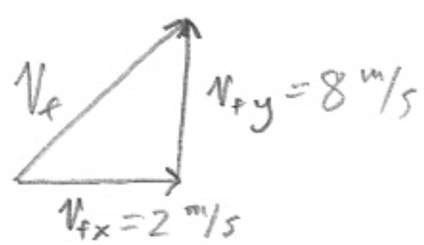
$$V_{fx} = 2 m/s$$

$\boxed{y}$

$$m_1 V_{10y} + m_2 \cancel{V_{20y}}^{0} = (m_1 + m_2) V_{fy}$$

$$16 \cancel{kg} m/s = 2 \cancel{kg} V_{fy}$$

$$V_{fy} = 8 m/s$$



$$V_f = \sqrt{8^2 + 2^2}$$

$$= \sqrt{68}$$

$$\boxed{V_f = 8.25 m/s}$$

11. Alex throws a 0.15 kg rubber ball down onto the floor. The ball's velocity just before impact is 6.5 m/s, and just after is 3.5 m/s. If the ball is in contact with the floor for 0.025 second, what is the magnitude of the average force applied by the floor on the ball?

$m = .15\,kg$

a. 30 N
b. 100 N
c. 18 N
d. 60 N
e. 24 J

$v_i = -6.5\,m/s$

$v_f = 3.5\,m/s$

$\Delta t = 0.025\,s$

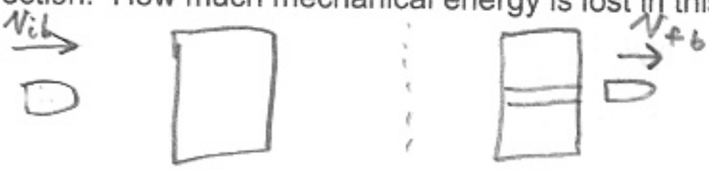
$$\vec{F}\Delta t = m\vec{v}_f - m\vec{v}_i$$

$$F = \frac{mv_f - mv_i}{\Delta t}$$

$$F = \frac{.15\,kg\,(3.5\,m/s + 6.5\,m/s)}{.025\,s}$$

$$F = 60\,N$$

~~12. A~~ 10 g bullet with an initial speed of 100 m/s is fired horizontally into a 90 g wooden block initially at rest on a frictionless horizontal surface. The bullet passes completely through the block and emerges with a final speed of 20 m/s in the horizontal direction. How much mechanical energy is lost in this process?



a. 50 J
b. 44.4 J
c. 36.1 J
d. 20 J
e. 15 J

$m_b = 10\,g$ $\qquad m_{block} = 90\,g$

$v_{ib} = 100\,m/s$

$v_{fb} = 20\,m/s$

This test may not be posted to the internet except by the author.

Part C: Answer following multi-part problem and show all work. (25 points).

15. A 0.5 kg wooden block, starting from rest, slides down a 2 m frictionless ramp inclined at 35° to the horizontal (see sketch below). At the bottom of the incline it collides with and sticks to a 1 kg block. The two blocks then slide up a second ramp inclined at the same angle as the first.

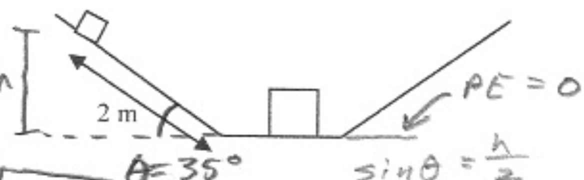
A. What is the speed of the first wooden block at the bottom of the incline before the collision?

$W_{nc}^{\to 0} = \Delta K_E + \Delta P_E$

$= K_{Ef} - \cancel{K_{Ei}}^{0} + \cancel{P_{Ef}}^{0} - P_{Ei}$

$P_{Ei} = K_{Ef} \longrightarrow \cancel{m}gh = \frac{1}{2}\cancel{m}v^2$

$v = \sqrt{2gh} = \boxed{4.7\ m/s}$

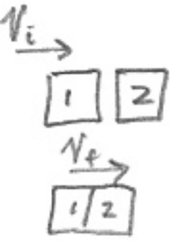


$\sin\theta = \frac{h}{2}$

$h = 2\sin 35°$

$h = 1.14\ m$

B. What is the speed of the two blocks after the collision?



$m_1 v_i + m_2 v_i^{\to 0} = (m_1 + m_2) v_f$

$.5\ kg(4.7\ m/s) = (.5\ kg + 1\ kg) v_f$

$\boxed{v_f = 1.6\ m/s}$

C. What is the work done on the 0.5 kg block during the collision?

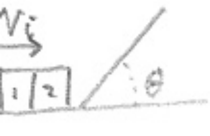
$W_{nc} = K_{Ef} - K_{Ei} + \cancel{P_{Ef}}^{0} - \cancel{P_{Ei}}^{0}$

$W_{nc} = K_{Ef} - K_{Ei} \longrightarrow W_{nc} = \frac{1}{2}(.5)(1.6)^2 - \frac{1}{2}(.5)(4.7)^2$

$W_{nc} = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

$\boxed{W_{nc} = -4.9\ J}$

D. How far up the second ramp do the blocks slide?



$W_{nc}^{\to 0} = \cancel{K_{Ef}}^{0} - K_{Ei} + P_{Ef} - \cancel{P_{Ei}}^{0}$

$K_{Ei} = P_{Ef}$

$\frac{1}{2}\cancel{m}v^2 = \cancel{m}gh \longrightarrow h = \frac{v^2}{2g}$

$h = \frac{(1.6)^2}{2(9.8)} \boxed{= .13\ m}$

E. How much mechanical energy is lost during the collision and where did it go?

The ramp is frictionless, so the energy is tranferred between kinetic and potential, no energy is lost!