Physics 1205 – Exam #3
November 14, 2008

Name (Print): key

My signature below is a statement that all work contained in this exam is my own work. I have not copied work from any other source, or used any material other than one 3 by 5 card and my calculator.

Name (Signature):______________________________

DO NOT TURN THIS PAGE OVER UNTIL YOU ARE INSTRUCTED TO DO SO.

STOP WORKING ON THIS EXAM AS SOON AS YOU ARE INSTRUCTED TO DO SO.

You will have approximately 1 hour to do this exam

- The following exam consists of 8 multiple-choice questions and 2 worked problems.
  - Point values are assigned to each problem in the exam.
- It is a good idea to first skim through the entire test and begin with the problems that seem most familiar. If you get stuck on a problem, skip to another.
- For the computational problems, please show all problem solving steps and all your work.
  - All work must be done on the pages provided.
  - Please write neatly and put a BOX around your final answer.
  - Use significant figures in your answers.
- Calculators may be used only to do arithmetic. You cannot use your calculator for solving algebraic equations, for graphing, for vectors, etc.

Problem #	Max Points	Score	Problem #	Max Points	Score
1	5		6	5	
2	5		7	5	
3	5		8	5	
4	5		9	30	
5	5		10	30	
			Total	100	

Choose the one best answer for each of the multiple choice questions.

1. A 10-kg object undergoes a displacement $\Delta \mathbf{s} = 6\hat{\mathbf{i}} - 4\hat{\mathbf{j}} + 2\hat{\mathbf{k}}$. During the displacement, a constant force $\mathbf{F} = -3\hat{\mathbf{i}} + 6\hat{\mathbf{j}} + 7\hat{\mathbf{k}}$ acts on the object. All values are given in SI units. The work done by the force $\mathbf{F}$ on this object (in Joules) is

$W = \vec{F} \cdot \Delta\vec{s} = 6(-3) + (-4)(6) + (2)(7)$
$= -28$

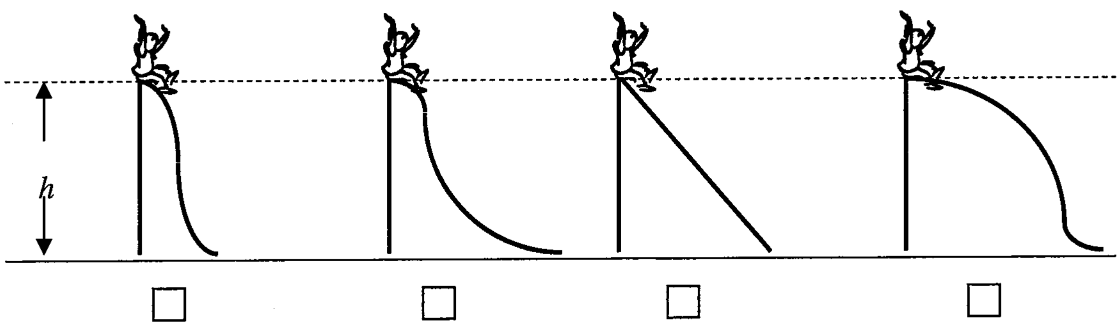
☒ −28 ☐ −280
☐ 56 ☐ 560
☐ $18\hat{\mathbf{i}} + 24\hat{\mathbf{j}} - 14\hat{\mathbf{k}}$ ☐ $-18\hat{\mathbf{i}} - 24\hat{\mathbf{j}} + 14\hat{\mathbf{k}}$

2. Two planets, Boomer and Sooner, have the same size, but different mass. If Boomer has twice the mass of Sooner the ratio of the escape speed of Boomer to that of Sooner is

$U_i + K_i = U_f + K_f$
$-\frac{GMm}{r} + \frac{1}{2}mv^2 = 0 + 0$
$v = \sqrt{\frac{2GM}{r}}$
when $M \to 2M$
$v \to \sqrt{2}v$

☐ 1/2 ☐ $1/\sqrt{2}$
☐ 1 ☒ $\sqrt{2}$
☐ 2

3. A young girl wishes to select one of the *frictionless* playground slides illustrated below to give her the greatest possible speed when she reaches the bottom of the slide. Which of the slides illustrated in the diagram should she choose?



☒ It doesn't matter. Her speed would be the same for each of the slides.

4. If a car can accelerate from 0 mph to 20 mph in 2.0 seconds, how fast can it accelerate from 20 mph to 40 mph assuming the power is constant and that all the work done by the engine is used to accelerate the car?

$P = \frac{W_{net}}{t} = \frac{\frac{1}{2}mv^2}{t}$

$t = \frac{mv^2}{2P}$

☐ 1.0 s ☐ 2.0 s
☐ 3.0 s ☐ 4.0 s
☒ 6.0 s ☐ 8.0 s

when $v \to 2v$, $t \to 4t$
So total time is $4t$,
Time from $20 \to 40$ is
$4t - t = 3t = (3)(2) = 6$

5. While watching a football game, you observe a crushing tackle made by an OU linebacker on an opponent's halfback while both players are firmly in contact with the ground. Which of the following is true?

- [x] Linear momentum is conserved. (always)
- [ ] The total kinetic energy is conserved. (no)
- [ ] Linear momentum is conserved only if the system is properly defined. (no - system helps solve problem easier)
- [ ] The impulse of the linebacker on the halfback is equal to the change in momentum of the halfback. No - because friction also acts on halfback
- [ ] More than one of the above is true.

$\int \vec{F}_{(net-ext)}\, dt = \Delta \vec{p}$

6. A sled of mass M is coasting on a level frozen river of ice, with no friction. While passing under a bridge, a package with the same mass as the sled, M, is dropped straight down and lodges in the sled without causing any damage. The sled plus the package then continue along the original direction of motion. How does the kinetic energy of the sled plus package compare with the original kinetic energy of the sled?

- [ ] It is one-fourth the original kinetic energy of the sled.
- [x] It is one-half the original kinetic energy of the sled.
- [ ] It is three-fourths the original kinetic energy of the sled.
- [ ] It is the same as the original kinetic energy of the sled.
- [ ] It is twice the original kinetic energy of the sled.

Along horizontal, $\vec{p}$ is conserved

$p_i = p_f$

$Mv = 2Mv' \Rightarrow v' = \frac{1}{2}v$

$\frac{K'}{K} = \frac{\frac{1}{2}(2M)(\frac{1}{2}v)^2}{\frac{1}{2}Mv^2} = \frac{1}{2}$

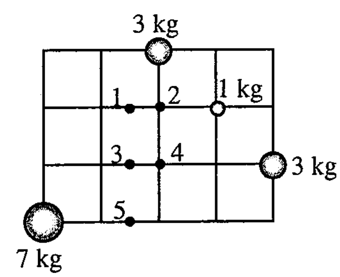
7. A light car and a heavy pickup truck are both out of gas. You push both the car and the truck for the same amount of time with the same constant force. Ignoring friction what can you say about the momentum and kinetic energy of the car and the truck after you have pushed them?

- [ ] They have the same momentum and the same kinetic energy.
- [ ] The truck has more momentum and more kinetic energy than the car.
- [ ] The car has more momentum and more kinetic energy than the truck.
- [x] They have the same momentum, but the car has more kinetic energy than the truck.
- [ ] They have the same momentum, but the truck has more kinetic energy than the car.

$\vec{P}_f = \int \vec{F}\, dt$

$K = \frac{p^2}{2m}$

8. The center of mass of the system of particles shown in the diagram is closest to point



- [ ] 1
- [ ] 2
- [x] 3
- [ ] 4
- [ ] 5

Along x: $x_{cm} = \frac{(3)(2) + (1)(3) + (3)(4)}{14} = \frac{21}{14} = 1.5$

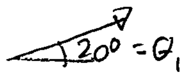
Along y: $y_{cm} = \frac{(3)(1) + (1)(2) + (3)(3)}{14} = \frac{14}{14} = 1$

9. In the battle of Gettysburg during the Civil War, the gunfire was so intense that several bullets were found that had collided in midair and fused together. Suppose a 5.00-g Union musket ball was moving to the right at a speed of 250 m/s 20.0° above the horizontal, and that a 3.00-g Confederate musket ball was moving to the left at a speed of 280 m/s, 15.0° above the horizontal.
   a) Immediately after the collision, what is the velocity of the fused musket balls?
   b) How much thermal energy was generated in the collision?

Before

After

a)



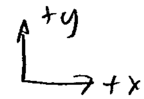
$15° = \theta_2$

$m = m_1 + m_2$

$\vec{V}_f = ?$

$V_{1i} = 250\ m/s$ $\quad V_{2i} = 280\ m/s$

$m_1 = 5g$ $\quad m_2 = 3g$



$\vec{I}_{ext} = 0 \Rightarrow \vec{P}_i = \vec{P}_f$

in x: $\Sigma P_{ix} = \Sigma P_{fx}$

$m_1 V_{1i} \cos\theta_1 - m_2 V_{2i} \cos\theta_2 = m V_{fx}$

$V_{fx} = (m_1 V_{1i} \cos\theta_1 - m_2 V_{2i} \cos\theta_2)/m$

$= \dfrac{(5g)(250\ m/s)(\cos 20°) - (3g)(280\ m/s)(\cos 15°)}{8g} = 45.4\ m/s$

in y: $\Sigma P_{iy} = \Sigma P_{fy}$

$m_1 V_{1i} \sin\theta_1 + m_2 V_{2i} \sin\theta_2 = m V_{fy}$

$V_{fy} = m_1 V_{1i} \sin\theta_1 + m_2 V_{2i} \sin\theta_2 / m$

$= \dfrac{(5g)(250\ m/s) \sin 20° + (3g)(280\ m/s)(\sin 15°)}{8g} = 80.6\ m/s$

$V_f = \sqrt{V_{fx}^2 + V_{fy}^2}$ $\quad \theta = \tan^{-1} \dfrac{V_{fy}}{V_{fx}} = \boxed{60.6° \text{ above } +x \text{ axis}}$

$= \boxed{92.5\ m/s}$

b) $\frac{1}{2} m v_f^2 - \frac{1}{2} m_1 v_{1i}^2 - \frac{1}{2} m_2 v_{2i}^2 = \frac{1}{2}(.008\ kg)(92.5\ m/s)^2 - \frac{1}{2}(.005\ kg)(250\ m/s)^2$

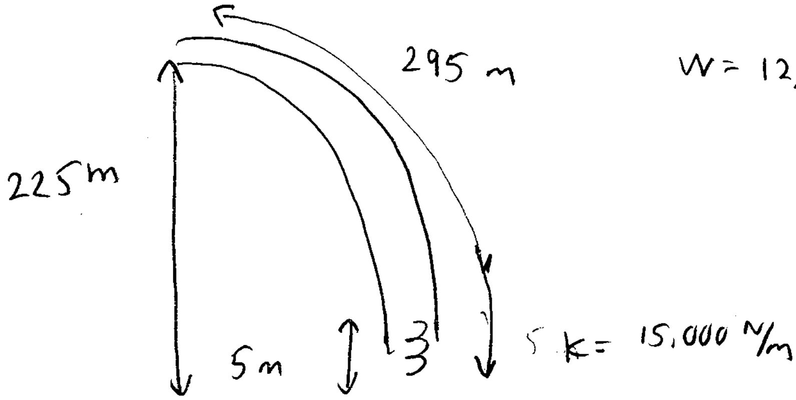
$- \frac{1}{2}(.003\ kg)(280\ m/s)^2 = \boxed{-240\ J}$

10. You are working as an intern at an architectural design firm and have been asked to help with the safety design of an elevator that will be installed in an arch-shaped monument (similar to the Gateway Arch in St. Louis). The elevator has two safety features that help prevent injury in case of a catastrophic failure of the cables that hold the elevator. If the cable were to break while the elevator was at its highest point, 225 meters vertically above the bottom of the shaft, the first safety feature is a frictional braking system that would prevent the elevator from gaining too much speed before reaching the bottom of the shaft. The second safety feature is a large vertical spring that stops the elevator's motion at the bottom of the shaft. The spring has a spring constant of 15,000 N/m and when fully compressed a distance of 5.00 meters, is flush with the bottom of the shaft. The maximum weight of the elevator and its cargo is 12,000 N. Because of the shape of the arch, the elevator actually travels a distance of 295 meters when it drops the 225 meters in elevation. If the elevator were to drop from its highest point, what average braking frictional force would cause the elevator to completely compress the spring and bring the elevator to rest at the bottom of the shaft? (As part of the final evaluation of your answer, roughly estimate the speed of the elevator just before it hits the spring, after it has fallen 220 meters in elevation.)

(You must solve this problem using the Context-Rich Problem work sheets starting on the next page. Partial credit will be given on this problem for steps performed correctly. For this problem, once a significant mistake is made no more credit will be given for any part of the problem, even if it is done correctly.)

FOCUS the PROBLEM

Draw a Picture Using ALL Given Information



W = 12,000 N

Questions(s)

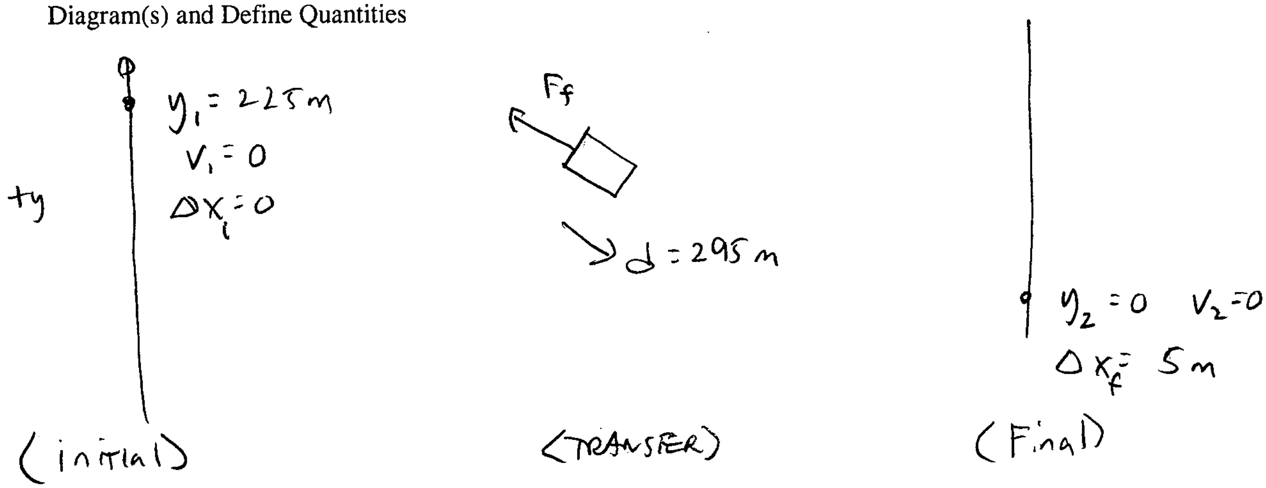
What average braking force just compresses the spring

Approach

Use cons of energy with dissipative forces

DESCRIBE the PHYSICS

Diagram(s) and Define Quantities



Target Quantity(ies)

F_f

Quantitative Relationships

$W_{ext} = \int \vec{F}_{ext} \cdot d\vec{r} = \Delta E$ $\quad E = K + U$

$K = \frac{1}{2}mv^2$ $\quad U = mgy + \frac{1}{2}k\Delta x^2$

PLAN the SOLUTION
Construct Specific Equations (Same Number as Unknowns)

Find F_f

$W = F_f d \cos 180 = \Delta E_U$

$-F_f d = \cancel{\frac{1}{2}mv_f^2}^{0} - \cancel{\frac{1}{2}mv_i^2}^{0} + \cancel{mgy_f}^{0} - mgy_i + \frac{1}{2}k\Delta x_f^2 - \cancel{\frac{1}{2}k\Delta x_i^2}^{0}$

$$F_f = \frac{mgy_i - \frac{1}{2}k\Delta x_f^2}{d} \qquad \boxed{F_f}$$

Check Units

$$\frac{\frac{[M](L)(L)}{(T)^2} - \frac{[F]}{(L)}[L]^2}{(L)}$$

$= (F) - (F)$ Force ok!

EXECUTE the PLAN
Calculate Target Quantity(ies)

$$F_f = \frac{(12{,}000\ N)(225\ m) - \frac{1}{2}(15{,}000\ \frac{N}{m})(5\ m)^2}{295\ m}$$

$= 8520\ N$

EVALUATE the ANSWER
Is Answer Properly Stated?

Yes, in Newtons

Is Answer Unreasonable?

After sliding 290 m + dripping 220 m

$w = -k_f + U_{gf} - U_{gi} = \frac{1}{2}mv^2 + mg(y_f - y_i)$

See extra space

Is Answer Complete?

Yes

(extra space if needed)

$$v = \left\{\frac{-2Fd}{m} - 2g(y_f - y_i)\right\}^{1/2}$$

$$= \left(\frac{2(8520)(290m)}{(12{,}000)/9.8\ m/s^2} - 2(9.8\ m/s^2)(5 - 225)\right)^{1/2}$$

$= 16.6\ m/s$ or ~ 37 mph

ok