General Physics I **Dr. Pogo**
SUNY Geneseo **October 21, 2008**

Exam #2

Name :_____

Instructions for the exam:

1) Use a pencil, not a pen.
2) Use at least 3 Sig Figs in all calculations.
3) The exam is closed book and closed notes. You may use your calculators. Also, formulae (which may or may not be useful) are provided on the last page of the exam.
4) Read each problem carefully. To receive partial credit, you must show all of your work. Include coordinate systems, equations, units, and pictures as needed. Put a box around your answers. You are not required to solve the problems in order, so if you get stuck, move on to another problem for a while.
5) There are four problems, most with several parts. The point value for each part is indicated in [square brackets].
6) Print your last name on every page.
7) For problems that take place on the surface of a planet, you may neglect air resistance and the effects of the planet's curvature.

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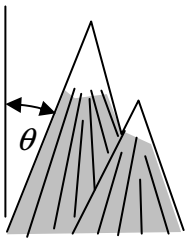
Problem #1: [43 points] Short Answers (a) through (p)

a. [5] Merlin was born when the planets Jupiter and Mars were in alignment. On that day, the distance to Jupiter was 7.5×10^{11} m, and the distance to Mars was 2.0×10^{11} m. The mass of Jupiter is 1.9×10^{27} kg, and for Mars, 6.4×10^{23} kg. What is the ratio of the force of Jupiter to the force of Mars as each acts on the baby Merlin?

b. [2] Sir Lancealot rides his horse at 7 m/s, heading east for ten minutes. The ground exerts normal forces and frictional forces on the horse's feet. The work done by the normal force on the horse is (choose one): [positive] [negative] [zero].

c. [2] For the same problem as part b, the work done by the frictional force on the horse is (choose one): [positive] [negative] [zero].

d. [2] While searching for the Holy Grail, Sir Galahad (m = 65 kg) climbs a tall mountain in 3 hours. The mountain is 1500m tall, and inclined at an angle of $\theta = 10°$ as shown. What is the work done by gravity on Galahad as he climbs?



e. [2] What is the average power needed?

f. [3] King Arthur rows out into a lake, looking for the sword Excaliber. The mass of Arthur and the boat together is 220kg. He starts at rest, and then by rowing, he does 4000J of work. Unfortunately, friction does -3600J of work during that same time. What is Arthur's final speed?

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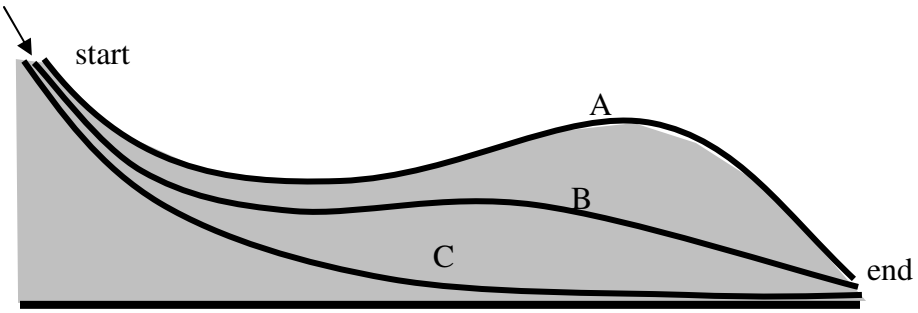
g. [3] Three knights at rest (A, B, and C), made clumsy by their armor, simultaneously fall and slip down a muddy (frictionless) hill. They all start at the same height, and the same initial slope before reaching the bottom. Rank the knights in terms of their final speed, from slowest to fastest.



h. [3] Rank the knights in order of their arrival (i.e., total time), from first to last

i. [3] Merlin is building Stonehenge. He pushes a large rock, using a force of 300N for 15 minutes, causing it to move 0.7m. Then he realizes it was in the right place before, so he pushes it back again, again pushing with 300N for another 15 minutes. What is the total work done by Merlin on this stone?

j. [2] When he's done, Merlin leans against the stone and rests. What was the total work done by all forces on this stone?

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k. [3] Sir Gawain is chasing Sir Percival around the Round Table, because Percival stole his dessert. If the diameter of his path is 8m, and the magnitude of his acceleration is 3 m/s^2, what is his speed?

l. [2] In the same problem, name the force that acts as the centripetal force on Gawain (i.e., is it weight, normal, friction, tension, elastic, etc.)?

m. [2] In the same problem, how much time is required to complete one loop around the table?

n. [3] Two jousting knights on horses collide with a terrible impact, and stick together in a tangle of limbs and lances. The mass of the first horse and its rider is m_A = 800 kg, and m_B = 1100 kg. Before the impact, group A had a speed of 17 m/s, and group B had a speed of 12 m/s. What is the final speed of the group just after the collision?

o. [3] King Arthur strikes a mighty blow at Mordred's stationary shield! The sword impacts the shield with a speed of 28 m/s. The collision is elastic, and the shield is far more massive than the sword. What is the final speed of the sword?

p. [3] King Arthur's sword now strikes Mordred's sword. The swords each have the same mass (neglect the hands that hold them). Before the impact, Arthur's sword has a speed of 28 m/s, and Mordred's has a speed of 24 m/s. The collision is elastic. What is the final speed of Arthur's sword?

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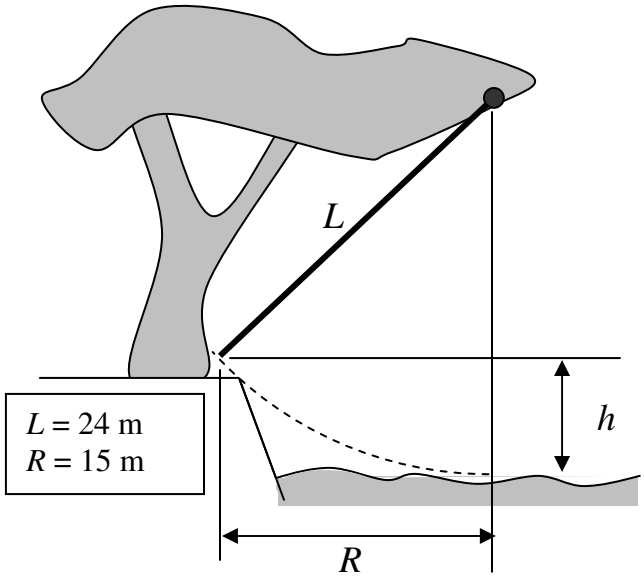
Problem #2: [8 points] To pull the sword (m = 12 kg) from the stone, Arthur exerts a steady vertical force of 650N. The sword comes out at constant speed. The coefficient of friction between the sword and the stone is μ_k = 2.4. What is the magnitude of the normal force exerted on the sword by the stone?

Problem #3: [15 points] Brave Sir Robin (m = 82 kg), fleeing from Gaulish raiders, approaches a river bank. Luckily, there is handy vine, and he swings down, just barely skimming the water at the bottom of his swing.

a. [3] How high is the cliff, h?
b. [6] What is his maximum speed?
c. [6] If the opposite bank is only half as high as he starts, what is his speed when he reaches it?



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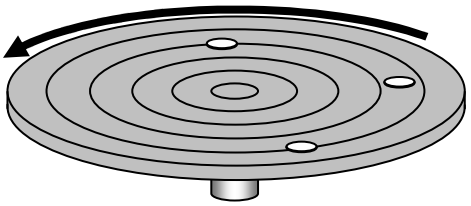
Problem #4: [17 points] Poor Sir Sagramore is gambling, which is why he is poor. In a certain establishment, bettors place their coins on a horizontal spinning disc. This turntable has a frequency of 0.42 Hz. The coefficient of friction between the disc and coins placed on it is μ_s = 0.18.

a. [3] What is the period of this rotation?
b. [7] What is the largest distance from the center of the turntable for which a coin will remain on the turntable without sliding?
c. [7] Suppose a coin is placed at r = 21cm. What is the acceleration of the coin?



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Problem #5: [17 points] A boulder (m_{tot} = 1000kg) is dropped from a castle wall, hitting the ground and breaking into 3 parts A, B, and C which move horizontally (see chart for speeds, etc., as viewed from above).

a. [3] Find m_C.
b. [9] Find v_C.
c. [5] Find θ_C.

m_A = 300 kg	v_A = 33 m/s	θ_A = 50°
m_B = 240 kg	v_B = 22 m/s	θ_B = 310°
m_C = ?	v_C = ?	θ_C = ?

Displacement, Speed, Velocity, and Acceleration

$\Delta x = x_2 - x_1$ (similarly for Δy, etc.)

$\bar{v}_x = \dfrac{\Delta x}{\Delta t} = \dfrac{x_2 - x_1}{t_2 - t_1}$ (similarly for $\bar{v}_y$, etc.)

$\bar{s} = \dfrac{\text{total distance}}{\Delta t}$

$s = \sqrt{v_x^2 + v_y^2}$

v_x = slope of x vs t plot

$\bar{a} = \dfrac{\Delta v}{\Delta t}$

a = slope of v vs t plot

Constant Acceleration

$x_f = x_i + v_{ix}\Delta t + \dfrac{1}{2}a_x \Delta t^2$

$v_{fx} = v_{ix} + a_x \Delta t$

$v_{fx}^2 = v_{ix}^2 + 2a_x\left(x_f - x_i\right)$

$x_f = x_i + \dfrac{1}{2}\left(v_{ix} + v_{fx}\right)\Delta t$

Projectile Motion

(assumes $+y$ is upwards)

$a_x = 0$

$a_y = -g$

$g = +9.8 \dfrac{\text{m}}{\text{s}^2}$

$\tan\theta_0 = \dfrac{v_{0y}}{v_{0x}}$

$v_{0x} = |v_0|\cos\theta_0$

$v_{0y} = |v_0|\sin\theta_0$

$y = y_0 + (x - x_0)\left(\dfrac{v_{0y}}{v_{0x}}\right) - \dfrac{g(x - x_0)^2}{2v_{0x}^2}$

or

$y = y_0 + (x - x_0)\tan\theta_0 - \dfrac{g(x - x_0)^2}{2(v_0\cos\theta_0)^2}$

$R = \dfrac{v_0^2}{g}\sin(2\theta_0)$

(destination and source at same height)

Work, Energy, Power

$W_F = F \cdot \Delta x \cdot \cos\theta$ (note $\cos 180^\circ = -1$)

$\Sigma W = KE_f - KE_i$

$KE = \dfrac{1}{2}mv^2$

$\bar{P} = \dfrac{W}{\Delta t} = F \cdot v$

$PE_{2g} = mgy_2$ if $+y$ is upwards

$E = KE + PE_g$

$E_2 = E_1 + W_{1\to 2,\text{all but gravity}}$, so:

$KE_2 + PE_2 = KE_1 + PE_1 + W_{1\to 2,\text{all but gravity}}$

Momentum & Impulse

$\vec{p} = m\vec{v}$

$\Sigma\vec{F} \cdot \Delta t = \Delta\vec{p}$

$\Sigma\vec{F}_x \cdot \Delta t = m\left(v_{fx} - v_{ix}\right)$

$\vec{p}_f = \vec{p}_i$ if $\Sigma\vec{F} = 0$

$\vec{J} = \Sigma\vec{F} \cdot \Delta t$

1D Elastic Collisions

$v_{1f} = \dfrac{m_1 - m_2}{m_1 + m_2}v_{1i} + \dfrac{2m_2}{m_1 + m_2}v_{2i}$

$v_{2f} = \dfrac{2m_1}{m_1 + m_2}v_{1i} + \dfrac{m_2 - m_1}{m_1 + m_2}v_{2i}$

Vectors

$\vec{A} = A_x\hat{x} + A_y\hat{y} + A_z\hat{z}$

$A = \left|\vec{A}\right| = \sqrt{A_x^2 + A_y^2 + A_z^2}$

$\theta = \arctan\left(\dfrac{A_y}{A_x}\right)$

$A_x = A\cos\theta$

$A_y = A\sin\theta$

Forces

Name an object or group of objects !!!!

$\Sigma F_x = ma_x, \quad \Sigma F_y = ma_y$

$W = mg$ (down)

$f_{s,\max} = \mu_s N$

$f_k = \mu_k N$

Gravity

$F = G\dfrac{m_1 m_2}{r^2}$

$G = 6.67\times 10^{-11}\dfrac{\text{Nm}^2}{\text{kg}^2}$

$T = 2\pi\sqrt{\dfrac{R^3}{GM}}$

Circular Motion

$|a_c| = \dfrac{v^2}{r}$ towards the center of the circle

$T = \dfrac{2\pi r}{v} = \dfrac{1}{f}$ (constant speed)

L or $s = r\Delta\theta$ (distance traveled, $\Delta\theta$ in radians)

$T = 2\pi\sqrt{\dfrac{R^3}{GM}}$ (orbits)