Physics 2101, First Exam, Fall 2006

September 5, 2006

Name : ____

SSN : ____

Signature : ____

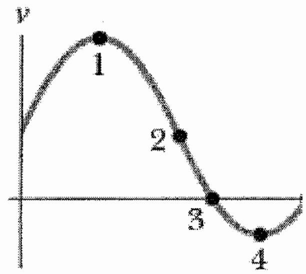
Section: (Circle one)

1 (Ahmad, MWF 7:40am)	4 (Lehner, TTh 9:10am)
2 (Rupnik, MWF 9:40am)	5 (Ahmad, TTh 12:10pm)
3 (Rupnik, MWF 2:40pm)	6 (Ahmad, TTh 6:10pm)

- Please be sure to write your name and circle your section above.
- For the *problems*, you *must* show all your work. Let us know what you were thinking when you solved the problem! Lonely right answers will not receive full credit, lonely wrong answers will receive no credit.
- For the *questions*, no work needs to be shown (there is no partial credit).
- Please carry units through your calculations when needed, lack of units will result in a loss of points.
- You may use scientific or graphing calculators, but you must derive your answer and explain your work.
- Feel free to detach, use and keep the formula sheet. No other reference material is allowed during the exam.
- **GOOD LUCK!**

Question 1 - 5 points

The figure shows the velocity of a particle moving along the x-axis. Point 1 is at the highest point in the curve; point 4 is at the lowest point.



(a) (1pts) What is the direction of motion at t=0?

towards positive x   towards negative x   the particle is at rest

(b) (2 pts) At which of the four numbered points does the particle reverse its direction of travel?

1   2   3   4

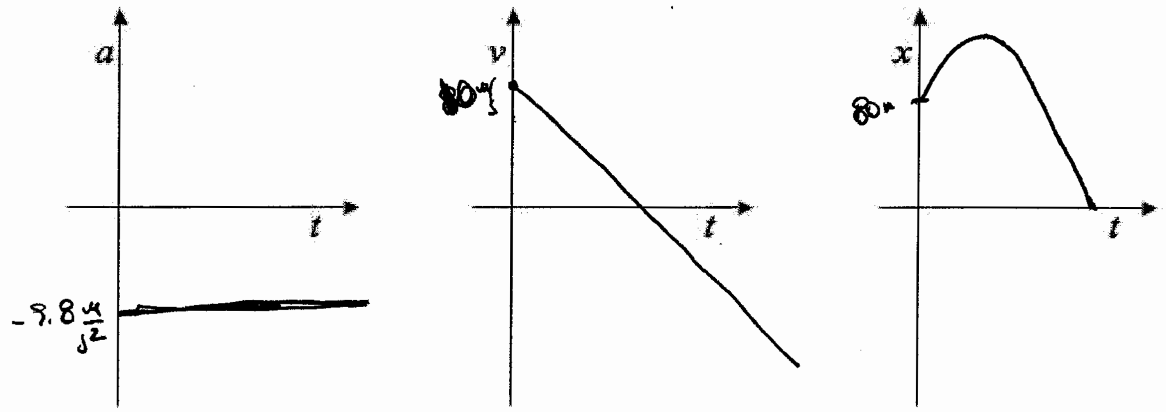
(c) (2 pts) At which of the four numbered points is the magnitude of the acceleration largest?

1   2   3   4

Problem 1 - 11 points

A hot air balloon is ascending at the rate of 10m/s and is 80 m above the ground when a package, which is at rest with respect to the moving balloon, is dropped from it.

(a) (3 pts) Sketch the acceleration, position, and velocity of the package as a function of time **after** it has been dropped from the balloon, setting t=0 at the time the package is dropped. Use the axes plotted below for your sketches.



(b) (4 pts) What is the maximum height above the ground reached by the package?

$a = -9.8 \frac{m}{s^2}$

$v(t_M) = 0 = -9.8\, t_M + 10 \Rightarrow$ $t_M = \frac{10 \text{ m/s}}{9.8 \text{ m/s}^2} = 1.02s$

$v(t) = -9.8 \frac{m}{s^2} t + 10 \frac{m}{s}$

$X(t) = -4.9 \frac{m}{s^2} t^2 + 10 \frac{m}{s} t + 80m$

$X(t_M) = -4.9 (1.02)^2 + 10 (1.02) + 80 = 85.10 \, m$

(c) (4 pts) How much higher than the package are the people in the balloon, when the package reaches maximum height?

BALLOON ascends at constant rate $\Rightarrow$ $v(t) = 10 \frac{m}{s}$

$X(t) = 10 \frac{m}{s} . t + 80m.$

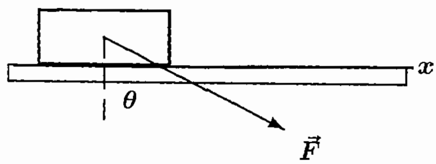
$X(t_M) = 10 \frac{m}{s} (1.02s) + 80 m$

$X(t_M) = 90.2 m$

$\Rightarrow$ Balloon is $90.2 - 85.1 = 5.1 m$ higher

Question 2 - 6 points

In the figure, the box is **stationary** and the angle θ between the vertical and force $\vec{F}$ is **decreased** somewhat. What happens to the following quantities during this change? Circle the correct answer.



(a) (2 pts) The horizontal component of the force, F_x

increases decreases remains the same

(b) (2 pts) The static friction, f_s

increases decreases remains the same

(c) (2 pts) The normal force, F_N

increases decreases remains the same

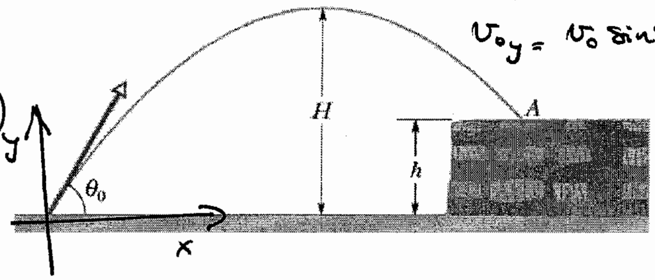
Problem 2 - 11 points

A stone is projected at a cliff of height h with an initial speed $v_0 = 42.0\text{m/s}$, directed at an angle $\theta_0 = 60^o$ above the horizontal, as shown in the figure. The stone strikes at A, 5.50 s after launching.

$\vec{a} = (0, g) = (0, -9.8 \frac{m}{s^2})$

$v_{0x} = v_0 \cos\theta = 42 \frac{1}{2} = 21 \frac{m}{s}$

$v_{0y} = v_0 \sin\theta = 42 \sqrt{\frac{3}{2}} = 36.4 \frac{m}{s}$



(a) (3 pts) What is the height h of the cliff?

Motion in x

$v_x(t) = 21 \frac{m}{s}$

$x(t) = 21 \frac{m}{s} \cdot t$

Motion in y

$v_y(t) = -9.8 \frac{m}{s^2} t + 36.4 \frac{m}{s}$

$y(t) = -4.9 \frac{m}{s^2} t^2 + 36.4 \frac{m}{s} t$

takes 5.5 s to reach h in y

$\Rightarrow y(5.5s) = -4.9 \frac{m}{s^2} (5.5s)^2 + 36.4 \frac{m}{s} 5.5s$

$y(5.5s) = 51.96\, m$

(b) (4 pts) What is the speed of the stone just before impact at A?

Speed $\rightarrow |\vec{v}| = \sqrt{v_x^2 + v_y^2}$

$v_x = 21 m/s \; ; \; v_y = -9.8 \frac{m}{s} (5.5s) + 36.4 \frac{m}{s}$

$v_x = 21 \frac{m}{s} \quad v_y = -17.5 \frac{m}{s}$

$\hookrightarrow |\vec{v}| = \sqrt{(21 m/s)^2 + (-17.5 \frac{m}{s})^2} = 27.3 \frac{m}{s}$

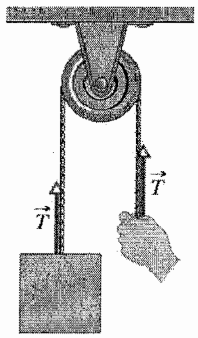
(c) (4 pts) How long after launching does the stone reaches the maximum height H above the ground?

Max height $\Rightarrow v_y = 0 \Rightarrow v(t_M) = 0 = -9.8 t_M + 36.4 = 0$

$\hookrightarrow t_M = \frac{36.4 \, m/s}{9.8 \, m/s^2} = 3.71 s$

Question 3 - 6 points

The suspended body in the figure has a mass M, and a weight equal to Mg. A person is applying a force to the other end of the cord. Is the magnitude of the tension T equal to, greater than, or less than Mg when the mass M is moving upward...



(a) (3 pts) ... at a constant speed?

$T = Mg$ $\quad$ $T > Mg$ $\quad$ $T < Mg$

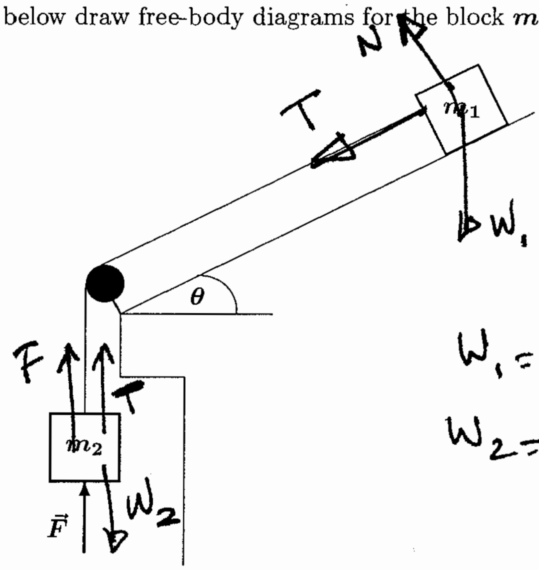
(b) (3 pts) ... at decreasing speed?

$T = Mg$ $\quad$ $T > Mg$ $\quad$ $T < Mg$

Problem 3 - 11 points

In the figure, a block of mass m_1 on a frictionless plane inclined at angle θ to the horizontal is connected to a box of mass m_2. The pulley is massless and frictionless. An upward force of magnitude $F = |\vec{F}|$ acts on the box m_2, which has a downward acceleration of magnitude $a = |\vec{a}|$.

(a) (4 pts) In the space below draw free-body diagrams for the block m_1 and the box m_2.



$W_1 = m_1 g$

$W_2 = m_2 g$

(b) (3 pts) Calculate the magnitude of tension, T, in the connecting cord, expressing your answer in terms of $m_2, a, F, g,$ and numerical constants, as necessary.

(For 1) $T + \sin\theta\, m_1 g = m_1 a$; (For 2) $-T - F + W_2 = m_2 a$

$\Rightarrow \boxed{T = -F + m_2 g - m_2 a}$

(c) (4 pts) Calculate the angle θ, expressing your answer in terms of $m_1, m_2, a, F, g,$ and numerical constants, as necessary.

Using (1) $T = m_1 a - m_1 g \sin\theta$

from (2) $T = -F + m_2 g - m_2 a$

equate

$m_1 a - m_1 g \sin\theta = -F + m_2 g - m_2 a$

$\Rightarrow m_1 g \sin\theta = (m_1 + m_2)a - g(m_2) + F$

$\Rightarrow \boxed{\sin\theta = \frac{1}{m_1 g}\left[(m_1+m_2)a - g\, m_2 + F\right]}$ (thus) $\theta = \sin^{-1}(A)$

$\underbrace{\qquad}_{A}$