Falcone Physics 8A

Fall 2002
Midterm # 1

Your name

Discussion session number / GSI name

1) DON'T OPEN THIS EXAM UNTIL INSTRUCTED TO BEGIN
2) Sit one seat away from anyone else
3) Do all your work on the page indicated for each problem
4) Show all work; don't just write an answer without showing your reasoning. **At the start of each problem, draw the free body diagram; show forces.**
5) This is a closed book exam
6) To simplify the math, take the acceleration due to gravity as $g = 10\ m/s^2$
7) In certain problems, you can give the answer in terms of the tangent of the angle, rather than the angle, in order to simplify the math (remember tangent is ratio of opposite to adjacent sides in a right triangle)
8) Possibly useful equations include:

$v = dx / dt$

$a = dv / dt$

$x = x_0 + v_0 t + 1/2\ a\ t^2$

$\Sigma F_i = m\ a$

$F_c = m\ v^2 / r$

$F_k = \mu_k N$

$W = F\ x$

$P = dW/dt$

$K = 1/2\ m\ v^2$

$U = m\ g\ h$

$U = 1/2\ k\ x^2$

$\Delta K = K_f - K_i$

$\Delta U = U_f - U_i$

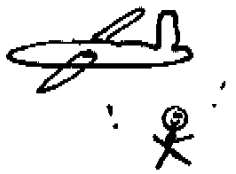
$W_{ext} = \Delta U + \Delta K + \Delta E_{th} + \Delta E_{int}$

Grading		
	#1	_____
	#2	_____
	#3	_____
	#4	_____
	#5	_____

1) A person with a closed parachute jumps out of an airplane and falls freely for **100 m**. The parachute then opens and the person decelerates at **2 m/s²**. The person reaches the ground with a speed of **3 m/s**.

a) How long was the person in the air?

b) At what height was the airplane flying?



a) $S = \frac{1}{2} a t^2$

$t = \sqrt{\frac{2S}{g}} = \sqrt{\frac{2 \cdot 100}{10}} = \sqrt{20} = 4.5\,s$

$v_0 = g t = 10(4.5) = 45\ m/s$

$v = v_0 + a t$

$3 = 45 - 2t$

$t = 21\,s$

$25.5\,s$

b) $y = y_0 + v_0 t + \frac{1}{2} a t^2$

$= 100 + 45(21) - \frac{1}{2}(2)(21)^2$

$= 100 + 945 - 441$

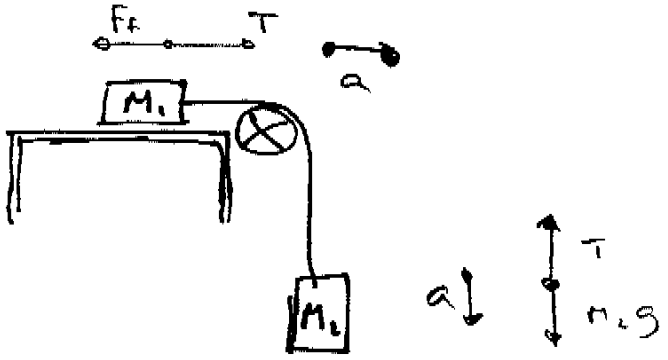
$= 604\,M$

2) Two masses, $\mathbf{m_1 = 30\ kg}$ and $\mathbf{m_2 = 20\ kg}$, are connected by a massless rope that has been placed over a massless pulley. Mass $\mathbf{m_1}$ sits on a table; it will experience friction when it slides along the table, with a coefficient of kinetic friction $\mu_k = \mathbf{0.4}$ Initially mass $\mathbf{m_1}$ is held still, and then it (and thus mass $\mathbf{m_2}$) is released to move.

a) What is the tension in the rope before the mass is released?

b) What is the tension in the rope after the mass is released?

c) How far does mass $\mathbf{m_2}$ fall in 5 s after release?



a) $T = M_2 g = 20 \cdot 10 = 200\,N$

b) $T - F_f = T - \mu M_1 g = M_1 a$

$M_2 g - T = M_2 a$

$M_2 g - \mu M_1 g = (M_2 + M_1) a$

$a = g\left(\frac{M_2 - \mu M_1}{M_1 + M_2}\right)$

$= 10\left(\frac{20 - 0.4(30)}{50}\right) =$

$a = \frac{80}{50} = 1.6$

$T = \mu M_1 g + M_1 a = M_1(\mu g + a) = 30(4 + 1.6) = 168\,N$

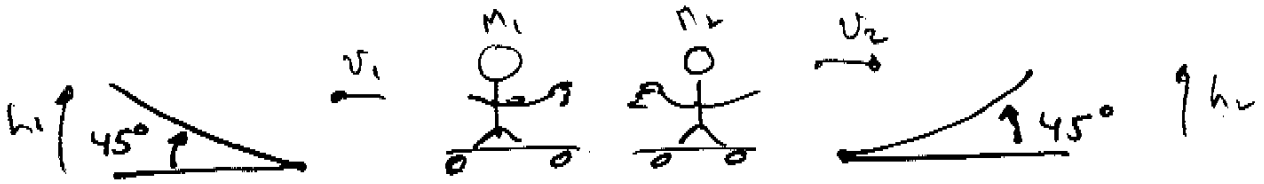
c) $S = \frac{1}{2} a t^2 = \frac{1}{2}(1.6)25 = 20\,M$

3) Person #1 and person #2, with masses $\mathbf{m_1 = 70\ kg}$ and $\mathbf{m_2 = 80\ kg}$, are standing on frictionless skateboards on level ground, with ramps at **45 degrees** to the horizontal behind them. The person with mass $\mathbf{m_1}$ pushes the other with a force $\mathbf{F = 500\ N}$ for a time $\mathbf{t = 0.5\ s}$

a) What is the maximum vertical height up the ramp that each person reaches?

b) How long does it take for each person to reach their highest point on their ramp?

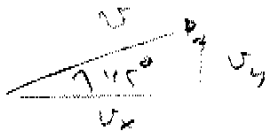
c) What is the velocity of each person, after they roll back down their ramps and collide with each other?



a) $F = M_1 a$

$a = F/M_1 = 500/70$

$v_1 = a t = \frac{500}{70} 0.5 = 3.6\ m/s$



$v_2 = \frac{500}{80} 0.5 = 3.1\ m/s$

$Mgh = \frac{1}{2} M v^2$

$h = \frac{v^2}{2g}$

$h_1 = \frac{(3.6)^2}{20} = 0.65\ m$

$h_2 = \frac{(3.1)^2}{20} = 0.48\ m$

b) $\frac{h_1}{v_1 \sin(45)} = \frac{0.65}{3.6}\sqrt{2} = 0.255$

$\frac{h_2}{v_2 \sin(45)} = \frac{0.48}{3.1}\sqrt{2} = 0.225$

c) $v_1 = 3.6\ m/s$

$v_2 = 3.1\ m/s$

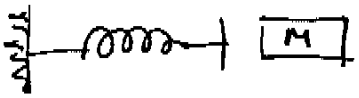
4) A mass **m = 2 kg** is placed at the end of a horizontal spring that has a spring constant **k = 500 N/m** and is compressed to a distance of **x = 0.1 m** from its relaxed point. The spring is then released, shooting the mass horizontally along a track. The mass starts up a **30 degree** incline with a coefficient of friction μ_k **= 0.4**

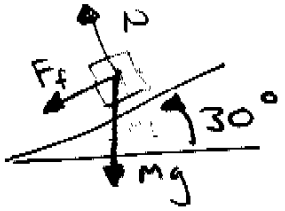
a) What is the initial energy of the mass shot forward by the spring?

b) What distance along the incline does the mass travel?

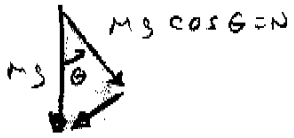
c) If the **coefficient of static friction is zero**, will the mass fall back down the ramp after reaching the top of its motion? Why?

d) If the mass does fall back onto the spring after sliding back down the ramp, how much will the spring be compressed?





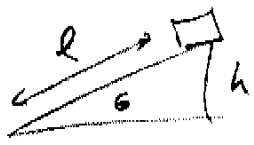
a) $\frac{1}{2} k x^2 = \frac{1}{2} 500 (0.1)^2 = 2.5\ J$



b) $\frac{1}{2} k x^2 = \mu (mg\cos\theta)\ell + mgh$

$2.5 = 0.4\,(2)(10)(0.87)\ell + 2(10)\ell(0.5)$

$\left[\frac{2.5}{7 + 10}\right] = \ell = 0.15\ m$



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

$\sin\theta = 0.5$

c) (yes) growth

d) $\mu mg\cos(\theta)\ell = 1.05\ J$

$2.5\ J - (2)1.05 = 0.45\ J = \frac{1}{2} k x^2$

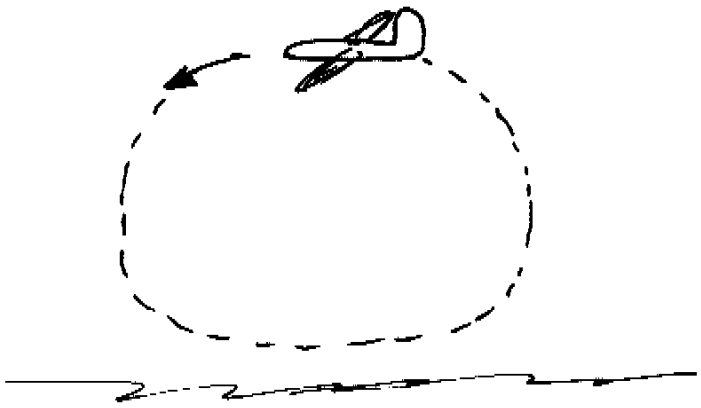
$x = 0.04\ m$

5) A pilot with a mass **m = 80 kg** is flying his aircraft in a vertical, circular loop at a speed of **v = 1500 m/s** at the lowest point in the loop (see diagram).

a) Find the minimum radius of the circular loop so that the pilot does not experience **centripetal acceleration** in excess of **6g**'s at the lowest point.

b) Find the force exerted by the pilot's seat on the pilot at the lowest point in the loop under conditions of part (a).

c) If the engine of the plane is suddenly turned off at the lowest point in the loop, but the airplane climbs upward, what is the maximum altitude that the plane could reach?



(a) $\frac{v^2}{r} = 6 \cdot 10$

$r = \frac{(1500)^2}{60}$

$r = 3.8 \times 10^4$ M

(b) $F = m6g + mg$

$= 80 \cdot 7 \cdot 10 = 5600$ N

7g's

(c) $\frac{1}{2}mv^2 = mgh$

$h = \frac{v^2}{2g}$

$= \frac{(1500)^2}{20}$

$= 1.1 \times 10^5$ M