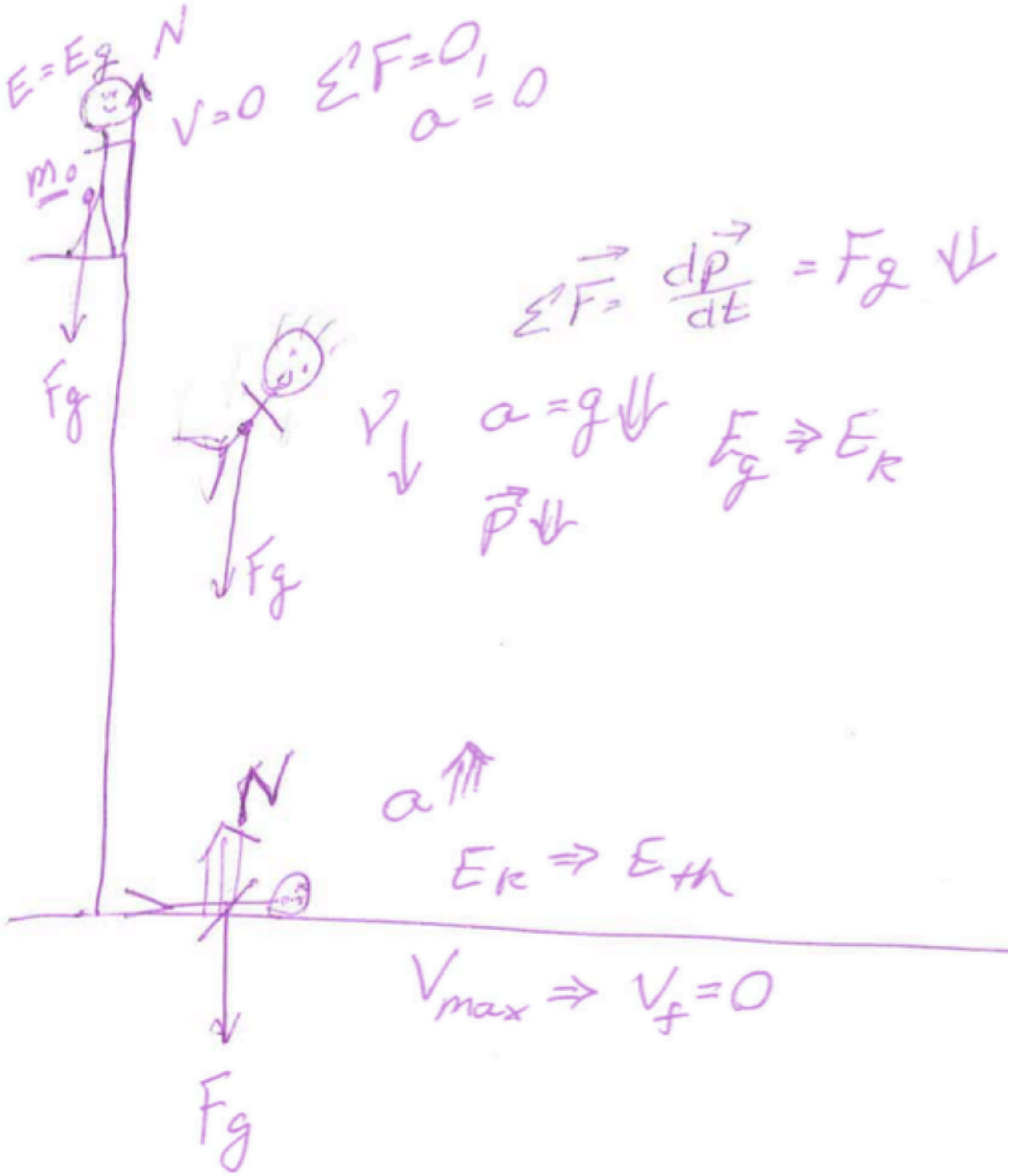
Problem Set #1 due beginning of class, Tuesday, Sept 27.

1. I inadvertently walk off a cliff. The process comes to a grim result 3 seconds later when I meet the ground. Please look at this process closely through all 4 lenses.
   I'm not going to allow the question to dictate how I look at this problem. I draw a picture as shown below and consider the lenses as I decide.



<u>Energy Lens:</u>
Gravitational potential energy transforms to kinetic energy and at the end is thermal energy in the slight increase in temperature to my body and rocks I land on.

<u>Forces, Dynamics and Momentum:</u>
Throughout the process, there is a force of gravity acting on me. We remember that when a net force acts on something, it accelerates (F=ma) and the momentum changes (F=dp/dt). However, at the beginning, there is a normal force provided by the ground, so there is no acceleration. After I step off the cliff, there is an "unbalanced force" of gravity because the normal force is gone, so my momentum increases due to this attractive force between me and the earth, and I accelerate. When I touch the ground, the normal force the earth provides is enough to prevent me from passing through the ground. There is huge acceleration as I come to rest (and die) in a very short time. Thus the normal force the earth provides must be very large to change my momentum so quickly.

<u>Momentum:</u>
Momentum is conserved. I am at rest in the beginning and end, but there is lots of momentum downward when I'm falling. My momentum increases and decreases due to the unbalanced forces provided by the earth. Thus we must consider the earth as part of the system. Our momentum together must be constant. In the beginning, our momentum is zero. As I fall downward, the earth is falling upward (due to the force of gravity attracting us), thus the vector sum or our momenta is still zero. When I hit the ground we both stop with final system momentum of zero.

Kinematics:

The velocity and acceleration are zero until I step off the cliff. After that, my acceleration is ~ 10 m/s^2 downward. My downward velocity increases smoothly until I hit the ground, and then rapidly comes to zero when I hit.

The acceleration when I hit the ground must be very high, as this is the rate of change of velocity. Also, as I fall, there may be increasing wind resistance, so the increasing upward force it provides will slightly lower my acceleration, and therefore the velocity time graph may have a slope that drops slowly in time as the velocity increases.

The velocity is the slope of the position ⇔ time graph. Thus, the position starts out at the top and stays there until I step off. Then it drops at an increasing slope, until the end, when the velocity is again zero, so the position stays constant thereafter.

In the graphs below, it is easiest for me to start with the acceleration graph because I know the acceleration should be about -10 m/s^2 while I am falling. Because wind resistance increases, my acceleration may drop a little at higher speeds… of course for sky divers, the wind resistance is enough to bring their acceleration to zero at over 50 m/s, so after about 5 seconds, they fall at almost constant velocity. We know that dv = a*dt, which is the area under the a⇔t graph. Because $v_o = v_f = 0$, the (negative) area under the curve while speeding up under gravitational acceleration must equal the (positive) area of slowing down under the spike. Thus the spike must be very high owing to the large acceleration and force that kills me at the end of the fall.

Then I can draw the velocity graph, with a constantly decreasing slope until I hit and come to rest.

Then I can draw the position ⇔ time graph.