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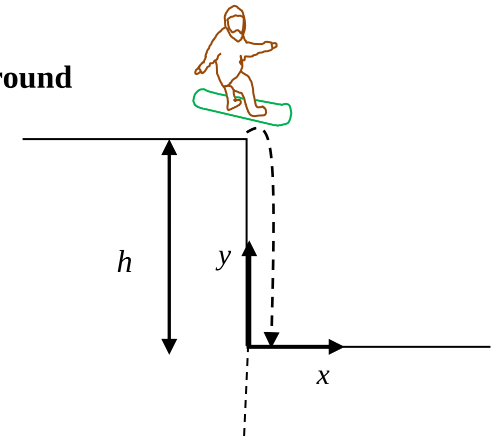
Problem – snowboarder- vertical cliff and horizontal ground

Consider a snowboarder of mass *m* who drops off a vertical cliff height *h* of 2.0 m onto hard horizontal snow. As the snowboarder lands they bend their knees dropping their center of mass an amount *b* of 0.25 m



a) What are the important forces exerted on the rider on landing? Draw a free body diagram of the person on landing.

b) Estimate the magnitude of the average acceleration of the person on landing and the average normal force F_N exerted on the snowboarder.

c) What is the time to fall and the time over which the normal force is exerted?

d) Draw a graph of F_N versus time during the landing. Show the assumed (average) form in this problem and show what you believe to be the true form.

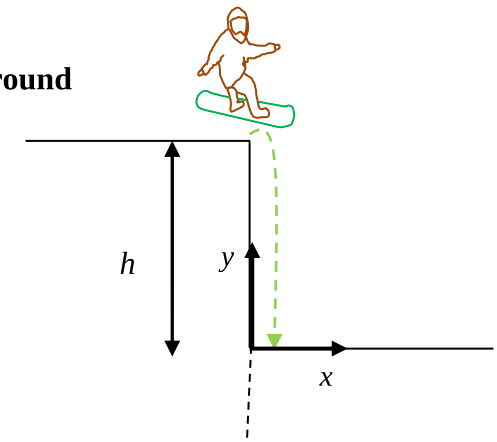
e) How would the effect of soft snow be incorporated? If the person were to sink 0.25 m in soft snow estimate, the new normal force.

f) How can we decrease the force further**?**

[solution on next page]

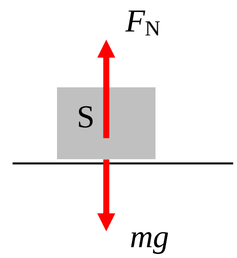
Solution – snowboarder- vertical cliff and horizontal ground

Consider a snowboarder of mass m who drops off a vertical cliff height h of 2.0 m onto hard horizontal snow. As the snowboarder lands they bend their knees dropping their center of mass an amount b of 0.25 m



a) What are the important forces exerted on the rider on landing? Draw a free body diagram of the person on landing.

Normal force, gravitational force.



b) Estimate the magnitude of the average acceleration of the person on landing and the average normal force F_N exerted on the snowboarder.

$a = (v_f^2 – v_o^2)/2b = gh/b$

Apply Newton's second law to rider during landing

ΣF_y: $F_N - mg = ma$

Using the above result for a, $F_N = mg(1 + h/b) = 9.0$ mg

This is a very large force and is probably not manageable!

c) What is the time to fall and the time over which the normal force is exerted?

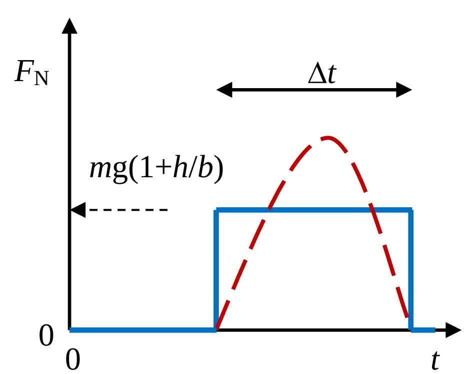
The time to fall is $y = y_o + v_o t + ½ at^2$ or $t_f = \sqrt{(2h/g)} = 0.64$ s.

The time over which this force is exerted can be calculated from the the average velocity during landing:

$v_{av} = (v + v_f)/2 = v/2$. Using $y \equiv -b = v_{av}(\Delta t)$ we obtain

$\Delta t = 2b/v = b\sqrt{(2/gh)} = 0.08$ seconds

d) Draw a graph of F_N versus time during the landing. Show the assumed (average) form in this problem and show what you believe to be the true form.



e) How would the effect of soft snow be incorporated? If the person were to sink 0.25 m in soft snow, estimate the new normal force.

As a first approximation this can be incorporated into b. e.g. sink into snow 0.2 m, $F_N = 5.0$ mg

This is a substantial decrease in F_N.

f) How can we decrease the force further**?**

Land on a slope!