Lecture 7 - Problem-solving

What's important:

- techniques for solving dynamics problems

Problem-solving

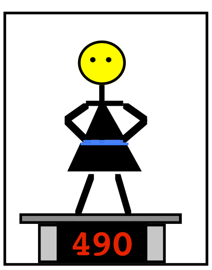
Here, we give a series of examples to illustrate the techniques for solving linear dynamics problems. All involve the construction of *free body diagrams*, in which each component is treated individually, recognizing all forces to which it is subjected.

#1. A woman of mass 50 kg is standing on a weigh scale in an elevator. What is the reading on the scale when the elevator is

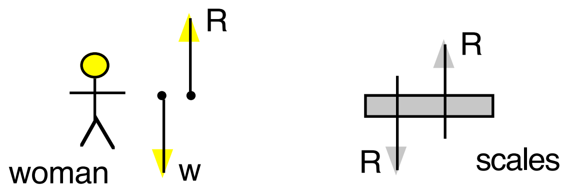
a) not accelerating
b) accelerating upwards at 3 m/s^2
c) accelerating downwards at 3 m/s^2

Solution:

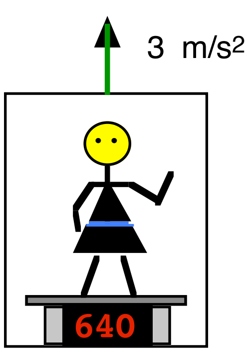
a)



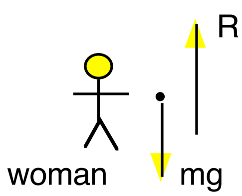
F on top of scales is $mg = 50 * 9.8$
$= 490$ N



b)



If the woman is accelerating upwards, then the reaction force from the scales must not only counteract her weight but must also accelerate her.

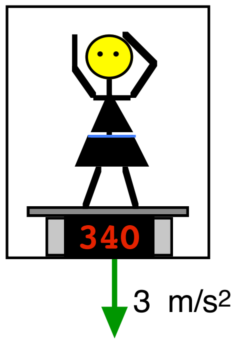


F on top of scales = $mg + ma$

$R = mg + ma$
$= 490 + 150 = 640$ N

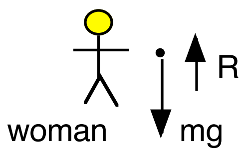
$R - mg$ is the force which accelerates the woman.

c)



If the woman is accelerating downwards, then the reaction force from the scales does not need to fully counteract her weight.

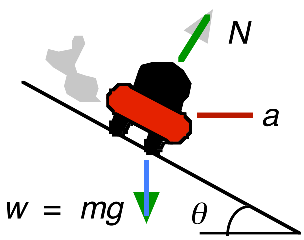
The downward force on the woman is mg - R.



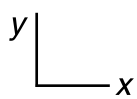
F on top of scales = mg - ma

R = mg - ma
= 490 - 150 = 340 N

#2. Car on a steep embankment, moving in a circle (like a track).



Here, the *x*-component of the normal force *N* provides the centripetal acceleration, so *N* must be larger than *mg* in magnitude.



In the *y*-direction,

$$N\cos\theta = mg$$

$$\Rightarrow N \geq mg$$

In the *x*-direction,

$$N\sin\theta = ma$$

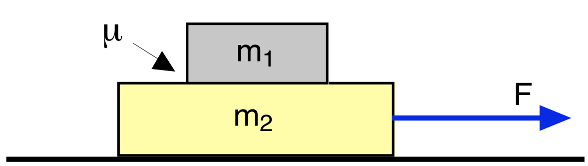
$$\Rightarrow a = g\tan\theta$$

$$v^2 = Rg\tan\theta$$

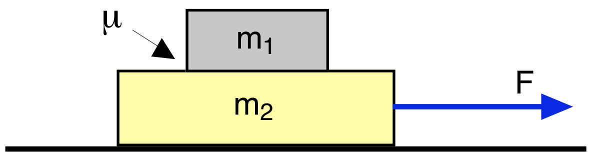
NOTE: this is different than a block sliding down a plane, where the acceleration **a** is parallel to the plane, not to the horizontal.

#3. Blocks subject to friction

A block of mass m_1 sits on another block of mass m_2, which in turn sits on a frictionless table. What is the maximum force that can be applied to m_1 such that m_1 will not slide with respect to m_2?



Solution:

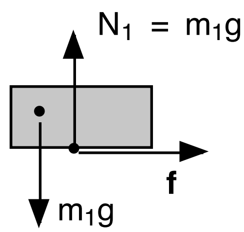


F results in an acceleration **a** of both blocks for $\mathbf{f} < \mu m_1 g$

$$\Rightarrow F = (m_1 + m_2)\,\mathbf{a}$$

Considering the top block only

m_1 :



$\mathbf{f} = m_1 \mathbf{a}$ and $\mathbf{f} \leq \mu m_1 g$

$\Rightarrow \mathbf{a} \leq \mu g$

$\therefore F \leq (m_1 + m_2)\,\mu g$