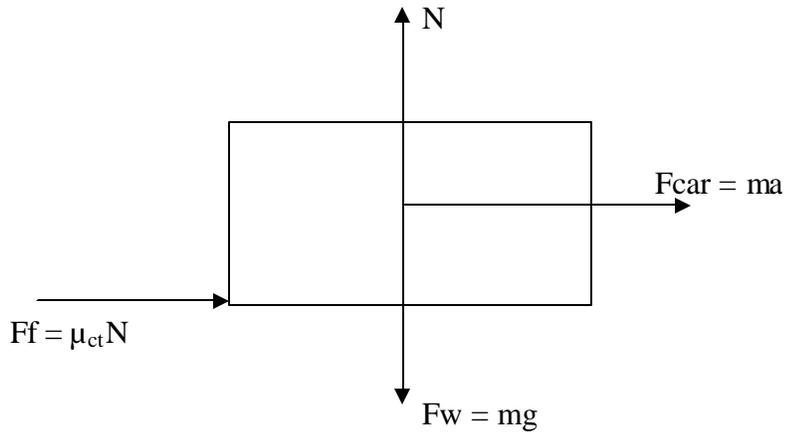


Problem Set 3: Newton's Laws of Motion, Motion: Force, Mass, and Acceleration, Vectors in Physics

Design Engineering Challenge: "The Big Dig" 2.007 Contest
Scoring **Concept** Investigation: Shot-Put Vehicle

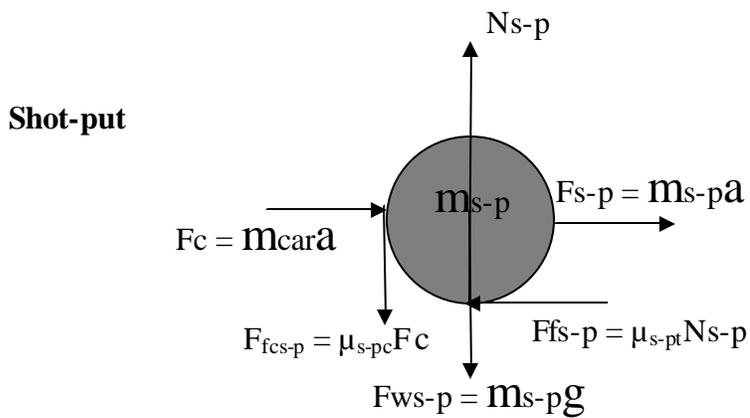
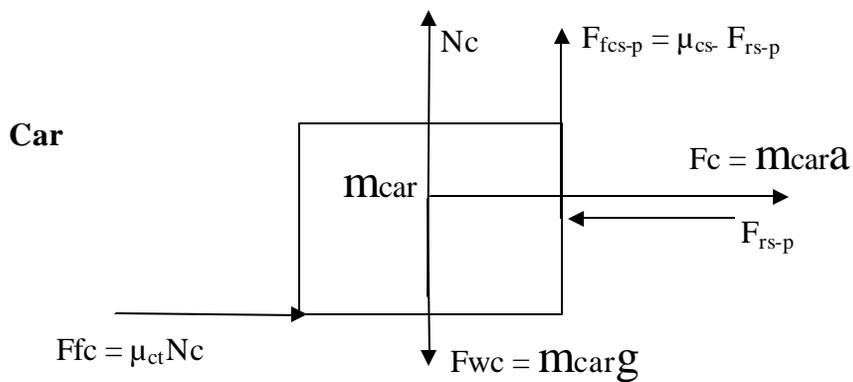
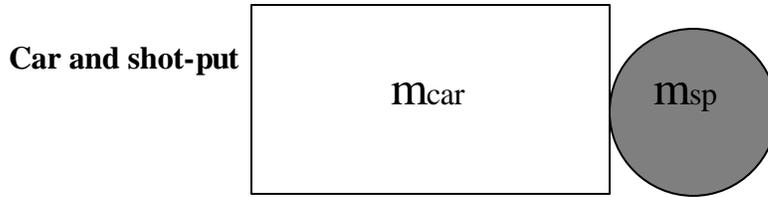
PROBLEM 1: Draw a free-body-diagram of a vehicle carrying a shot-put and accelerating towards the scoring bin

-Assume ball is fixed (not rolling) in car



m = mass of car + mass of shot-put, a = acceleration of care, μ_{ct} = friction coefficient between car and table

PROBLEM 2: Draw a free-body-diagram of a vehicle rolling a shot-put across the table and accelerating towards the scoring bin



F_{rs-p} = reaction force of the shot-put on the car, F_{fs-pc} = friction force between shot put and car

If no slipping of the shot-put occurs, $F_{fs-p} = 0$.

PROBLEM 3: Given that the tractive effort (ability accelerate without wheels slipping) is proportional to the normal force between the wheels and the ground and the coefficient of friction, is it better to get the shot-put onto your vehicle and then transport and dump it, or, should you push (roll) it to the scoring bin?

If the shot-put is loaded onto the vehicle, the weight of the vehicle will increase, in turn increasing the normal force on the vehicle and hence the frictional force, giving the vehicle more traction. However, one must be careful not to load too much weight onto the vehicle (i.e. more torque than the motors can handle, causing them to stall).

If the shot-put is pushed instead of loaded onto the vehicle, traction is less and the shot-put applies a reaction force on the vehicle. Trying to push too much weight will lead to slipping of the vehicles wheels.

PROBLEM 4: What are the risks of each strategy, and what are possible countermeasures?

Loading

Can lead to motors reaching the stall torque, or a slow moving vehicle. A countermeasure would be adding a reduced ratio gearbox to the wheel motors to compensate for the extra load.

Shot-put may roll off vehicle due to low friction between shot-put and vehicle. A countermeasure is to put side walls on the vehicle to contain the shot-put.

It may be difficult to load the shot-put onto the vehicle, in which case it would be necessary to push it as a countermeasure.

Car may tip when climbing incline. A countermeasure is to position the shot-put in the front of the vehicle, so that it is counterweighted from tipping.

It may be difficult to unload the shot-put, once it is loaded on the vehicle. A countermeasure would be adding a function to the vehicle that would incline the shot-put resting surface when unloading.

Pushing

There may not be enough traction to push the balls. A countermeasure would be adding a high friction material to the wheels, such as sandpaper, or rubber.

May be difficult to control the shot-put. A countermeasure is to add guide rails to the vehicle to control the path of the shot-put.

PROBLEM 5: Create a concept sketch of your design.

Concept sketch is a drawing of what you imagine your car to look like. Nothing fancy like a CAD drawing, just a hand sketch showing the major components of the car. The sketch below shows the base of the car that can hold balls and a pusher to move balls around. Also included in the drawing are brief descriptions of key components and their function.

