AMP(2)-Lab 04 – Dynamics

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# Learning objectives

## Exam objectives

By the end of this lab you should be able to (pen and paper):

* Apply the three Newton’s Laws of Motion
* Distinguish between weight (vector) and mass (scalar)
* Use and calculate the Normal force and apparent ‘weight’ (erratic mass)
* Understand the responsiveness of the Normal force

We advise you to **make your own summary of topics** which are new to you.

## Supportive objectives

Specifically related to the above you should in GeoGebra be able to:

* Calculate (displacements, velocities and) accelerations for Rectilinear Motions with Constant Acceleration
* Apply the location equation, the velocity equation and the time-independent formula for the Rectilinear Motion with Constant Acceleration
* Visualize all forces in View/Graphics
* Visualize the force-driven trajectories in View/GraphicsExercises

# Exercises

Dependent of the lab session you may work individually or teamed (organized by the lab attendant). In either case make sure that throughout the course of this lab, you re-save sufficiently your solution file on your local machine as

**1DAExx-0y-name1**(+name2+name3).GGB given **xx**=groupcode, **0y**=labindex

## Basic exercises

### Newtons Laws

* Write down Newtons 1st 2nd and 3rd Laws of Motion and explain them in your own words.
* Why does a child in a wagon seem to fall backward when you give the wagon a sharp pull forward?

### Newton’s 2nd Law of Motion (Momentum)

* What force is needed to accelerate a child on a sled, their total mass being 60 kg, over perfect ice at 1.25m/s2, ignoring friction? [Solution: 75 N]

F = m \* a = 60 kg \* 1.25 m/s2 = 75 N

### Newton’s 3rd Law of Motion (Action/Reaction)

* + When an object falls freely under the influence of gravity there is a net force exerted on it by the Earth. Yet by Newton’s third Law the object exerts an equal and opposite force on the Earth. How much does the earth get accelerated towards the falling person? (The falling person accelerates with g=9.81 m/s2 and has a mass of 85kg. Assume for the mass of the earth to be 5.9\*1024 kg) [Solution: 1.41\*10-22 m/s2]
* F(person) = m \* g = 85 kg \* 9.81 m/s2 = 863.28 N
* F(Earth) = m \* a → a = F(Earth) / m = 863.28 / 5.9 \* 1024 = **1.41\*10-22**

## Bridging exercises

### Constant Acceleration cases

* What force is needed to constantly accelerate a 42 g-bullet from rest to 923 m/s over a distance of 0.8 m along the barrel of a rifle? [Solution: 22363 N]

m = 42 g = 0.042 kg F = m \* a → F?

v2 = v02 + 2\* a \* s → 9232 = 02 + 2 \* a \* 0.8 → a = 9232 / 1.6 = 523.455,625 m/s

F = 0.042 kg \* 523.455,625 m/s = **22363 N**

* During the shot an equally large force gets applied on the shooter. How fast would an 85-kg person move if he shot the rifle in outer space? How is that force called? In what direction does the force point that is applied to the human? [Solution: 0.45m/s]

### Normal force

* A box is standing on a slope with an angle of 30o. The slope is covered with ice (ignore friction). What is the horizontal acceleration acting on the box? [Solution: 4.91m/s2]
* How fast does the box move sideways after 2 seconds have passed?
* The box weighs 10kg. How much Force is being applied on the box parallel to the slope.

### Weight vectors

* What is the weight (magnitude) of the same 76 kg-astronaut
  + on Earth where g = 9.8 m/s2 [Solution: 744,8 N]
  + on the Moon where g = 1.7 m/s2
  + on planet Mars where g = 3.7 m/s2
  + in outer space where g = 0 m/s2 whilst traveling with constant velocity?

### Apparent ‘weight’

* An elevator accelerates with 1 m/s2. What is the apparent ‘weight’ (erratic mass in kg) of a 85 kg-person standing on a scale when:
  + The elevator goes up. [Solution: 93.66 kg]
  + The elevator goes down. [Solution: 76.34 kg]

## Contextual practice

* Write down the formula that correlates force, mass and acceleration and the formula that correlates velocity to time and acceleration. Combine the two to get the correlation between force, mass, velocity and time.
* A space ship with the mass of 15 tons decelerates with constant deceleration from 6000 km/h to 1000 km/h in 2 seconds. How strong is the thrust of the boosters in kiloNewton? [Solution: 10416,66 kN]
* Two snow cats tow a house to a new location at Antarctica, as pictured by this top view. The sum of the force vectors and exerted on the house (which slides frictionless) by both cables is parallel to the line L. The magnitude FA = 4500 N
  + 1) Determine the other magnitude FB [Solution: 6894.6 N]
  + 2) Determine the net magnitude [Solution: 8863.44 N]



* The bullet of **exercise 3.2.1** was fired by a sniper lying on the ground. The height of the barrel above the ground is 0.3 m. How far does the bullet travel over flat terrain till it hits the ground (ignoring air friction) if:
  + The barrel was parallel to the ground. [Solution: 230.75 m]
  + The barrel was angled 1o upwards. [Solution: 3045.43]
* How much is the vertical hit velocity on the ground (in m/s) according to scenario 2 (i.e. the angled 1o shot)? The bullet then slows down in 0.2 seconds and is stuck 5 centimeters in the ground. What is the force (in N) on the bullet caused by its vertical impact, assuming constant deceleration of the bullet. [Solution: v=16.26 m/s, F = -111N]
* **An elevator** accelerates with a constant acceleration till it reaches its maximum velocity and then decelerates with the opposite acceleration till it reaches stand still again. It takes the elevator 10 seconds to go up 4 floors (equivalent of 15 meters). How much goes the so-called apparent ‘weight’ (erratic mass in kg) of a person of mass 60 kg displayed on a domestic scale during the ride (write down the values for each and every second)? [Solution: first 5 seconds: 63.67 kg, subsequently the last 5 seconds: 56.33 kg]