**Dynamics**:

Dynamics studies motion cause by the forces by solving differential equations of the Second Law of Newton to find the velocities and the displacements. In dynamics we integrate the differential equations.

There are 3 **Laws of Newton**:

The **First Law of Newton** is the law of **inertia**: a mechanical system does not change its momentum unless the force is applied to this mechanical system.

The **Second Law of Newton** for a material point says that **F** = m**a**, here **F** is the resultant force applied to the material point, m is the mass of the material point and **a** is the acceleration of the material point cause by the force **F**. **F** and **a** are vectors and m is a scalar.

The **Third Law of Newton** says that action is equal to reaction.

We consider the same projectile problem in dynamics as we did in kinematics when we mainly differentiated the equations of the motion to get the velocities and the accelerations. In dynamics we start with accelerations, then we integrate once to get the velocities, after that, we integrate the second time to get the displacements.

To prove our kinematics solution to the projectile problem, we start with the Second Law of Newton and integrate it to get the velocity and then the displacement.

A **free-body diagram** substitutes the constraints with the equivalent forces.

The **inclined plane** problem is solved by choosing the reference frame in which one of the coordinate axes is directed along the slant and the other coordinate axis is perpendicular to the slant.

For a material point at the inclined plane with inclination angle A and the friction coefficient μ, the motion starts when μ = tanA or A = arctan(μ).

If tanA μ then there will be no motion.

If tanA > μ then there will be motion down, in this case the resulting force down the slant is

F = mg(sinA - μcosA), here m is the mass of the material point and g is the gravity acceleration of the Earth.

For a uniform **circular** motion with constant speed v and radius R, the centripetal acceleration is .

The **Law of Gravity of Newton** is . This law allows us to calculate the force of gravitational attraction between the two masses and the gravity acceleration on Earth , here M is the mass of the Earth and R is the radius of the Earth.

The Law of Gravity of Newton is similar to the Law of Coulomb.

The orbital velocity is determined from equating the gravity force to the centrifugal force: , which gives us for the orbital velocity. This gives us the orbital velocity of approximately 8km/s for the Earth at its surface.

Equating the kinetic energy to the energy of the gravity force, we get the expression for the escape velocity: . This gives us the escape velocity of approximately 11km/s for the Earth at its surface.

The 3 **Laws of Kepler** are important in celestial mechanics and they are similar to the laws of quantum physics.

The **First Law of Kepler** says that a satellite moves in elliptic orbit with the star in one of the foci of the ellipse.

The **Second Law of Kepler** says that the satellite moves faster if it is closer to the star. The radius-vector of the satellite covers the same area in during the same period of time. The centrifugal force balances the gravity force, thus, the closer the satellite to the star, the faster the satellite must move in order not to fall to the star. This law is similar to the laws of quantum physics.

The **Third Law of Kepler** says that the cube of the mean radius of the satellite is directly proportional to the period squared and the constant of proportionality is known.

**Energy** is the ability to do the **work**:

The simplest expression for work is as follows: W = FD.

Another simple but more complicated expression for work is W = FDcosA, here A is the angle between the vectors of the force **F** and the distance **D**.

More general expression for work is:

**F** and **D** are vectors and their dot-product is calculated to find the work.

Kinetic energy .

Potential energy .

Elastic potential energy is as follows: .

Energy is measured in joules (j). j = Nm.

**Work-energy principle** says that some energy is used to do some work.

The energy is conserved for the **conservative forces**: KE + PE = C, here C is a constant.

Work of a conservative force does not depend on the path and depends only on the beginning and the end of the path.

Work of a conservative force in a round trip is zero.

A conservative force can be expressed as a derivative of some function P (potential).

Power is work per unit of time P = W/t or, more precisely, the derivative of work with respect to time: .