<div align="center">

«Mechanics And Machines»
Final Exam
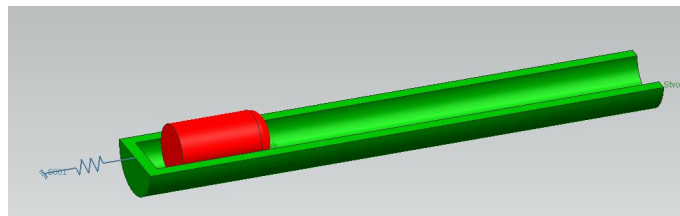*CAE part*
Variant: 1

</div>

Rifle simulation

Input data description:
Create a simplified geometric model of the bullet in the barrel of the rifle at the moment of firing (fig. 1a). Approximate parameters of the model:

- Bullet weight: 9 g.

- Barrel weight: 250 g.

- Gunpowder combustion force: 500 N.

- Powder combustion time: 0.01 s.

Task description description:

- Check the law of conservation of momentum at the moment of firing. Give graphs of the velocity of the bullet and the barrel — (fig. 1b).

- Determine the velocity of the bullet at the moment of departure from the barrel.

- Calculate (experimentally) the spring stiffness (fig. 1a) , which should bring the striker to its initial state in about 0.02 seconds after the shot. Give a graph of the movement of the striker at the moment of firing (fig. 1c). Determine the "recoil distance" of the striker.

(a)

(b)

(c)
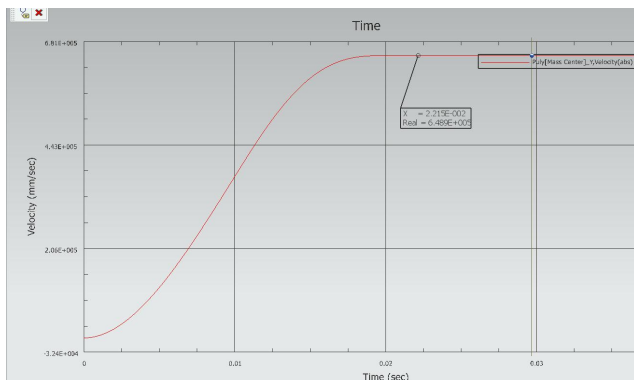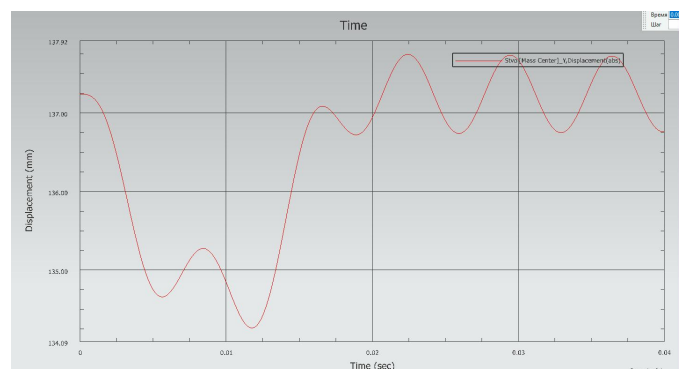
«Mechanics And Machines»
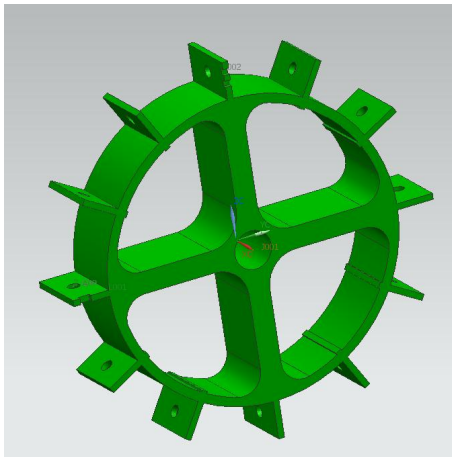# **Final Exam**
CAE part
Variant: 2

## **Waterwheel**

Input data description:

Create a geometric model of the water wheel (fig. 2a). The mass of the wheel is approximately 650 kg.
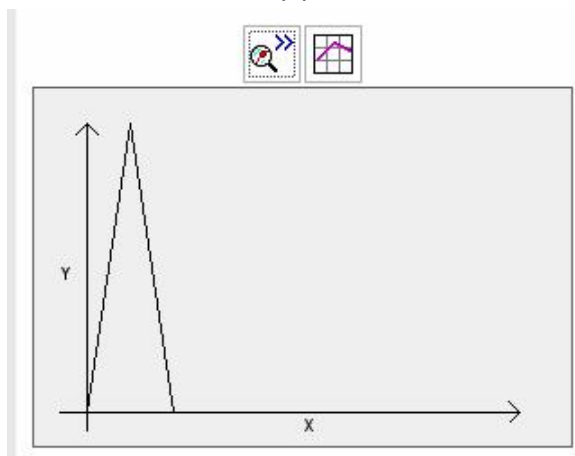
Task description description:

- Apply a single impulse force to one of its blades (fig. 2b), which acts only for 0.1 - 0.15 seconds (fig. 2c).

- Calculate or select the amount of force applied so that the wheel turns a quarter turn in about 2 seconds (fig. 2d).
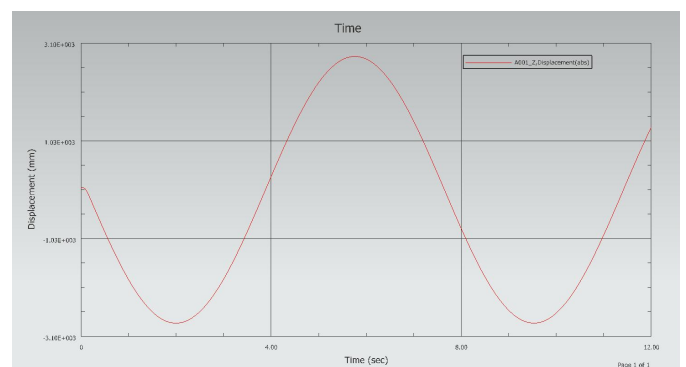

(a)

(b)

(c)


(d)
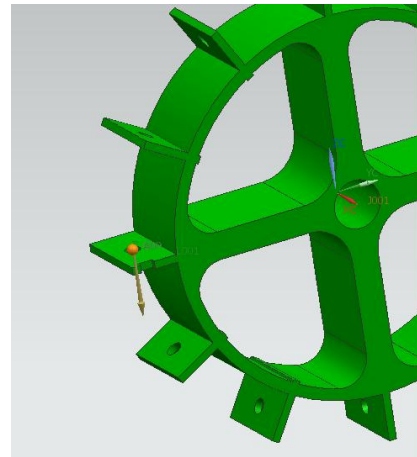
Modified moment of inertia

Input data description:
Create a geometric model of a simple mechanism (fig. 3a). The mass of the gray base is about 1 kg. The mass of the red weight is about 0.7 kg. The red weight can only move along the gray sled. The base rotates around fix based by external torque (approx 2000 Nmm)

Task description description: You should solve the task for 2 cases.

1. The red weight remains in place during rotation (for this purpose it is placed strictly in the middle), the angular velocity of the entire structure is constantly increasing.

2. The red load is somewhat shifted to the side (fig. 3b), then during rotation of the gray base, this load will "move away" under the action of centrifugal force, and because of the increased moment of inertia of the whole structure, the movement will quickly stop. In the figure (fig. 3c) shows a graph of angular velocity of the whole structure for this case.
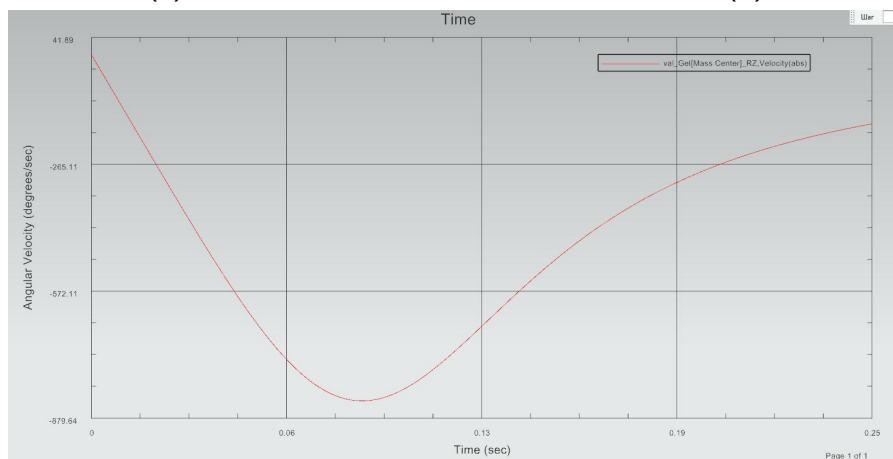
The task is to determine the maximum angular velocity of the structure that will be reached and the point in time when this maximum will occur.

(a)   (b)
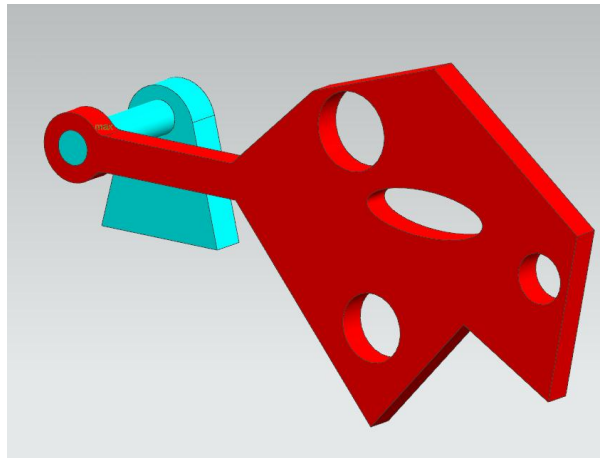

(c)

<div align="center">
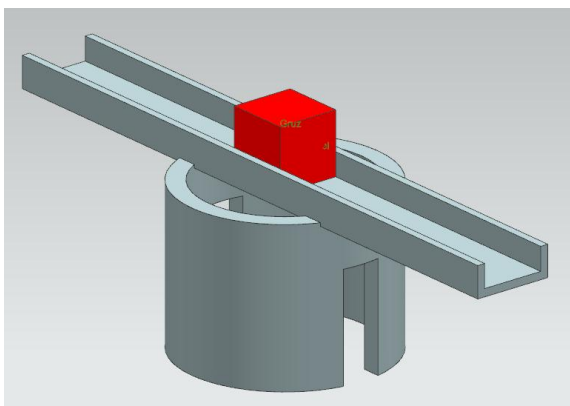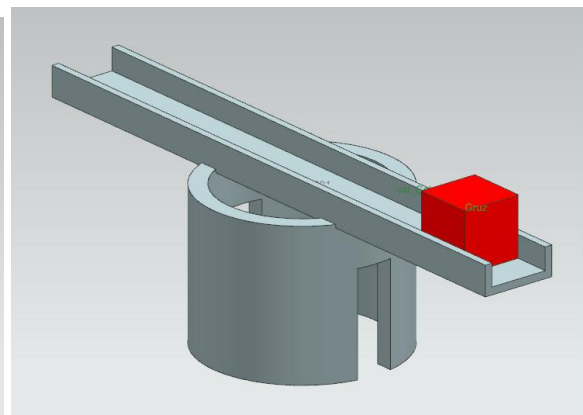
«Mechanics And Machines»
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CAE part
Variant: 4

</div>

Centrifugal force of flywheel
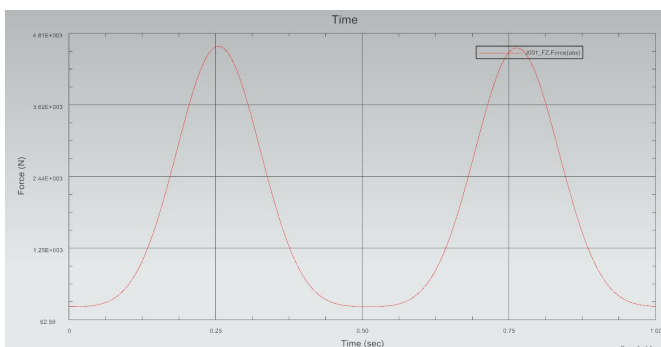
Input data description:
Construct a geometric model of a simple mechanism (fig. 4a). The geometry of the red fly-wheel can be completely arbitrary (but flat). The red flywheel swings by its own weight.
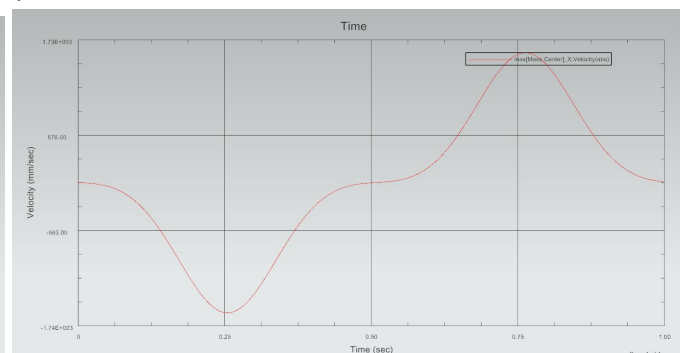**Task description description**:

- Determine the necessary mass-inertia characteristics of the red flywheel.

- Plot the reactive force in the rotational joint (fig. 4b).

- Plot the linear velocity of the center of mass of the flywheel (fig. 4c).

- Find the centrifugal force by $F = \frac{mv^2}{r}$, where m — flywheel mass, v — linear velocity of the flywheel, r — center of mass swing radius of the flywheel.

- Show that at a certain point in time the reactive force in the rotational joint is the weight of the flywheel, plus its centrifugal force.

(a)

(b)

(c)

«Mechanics And Machines»
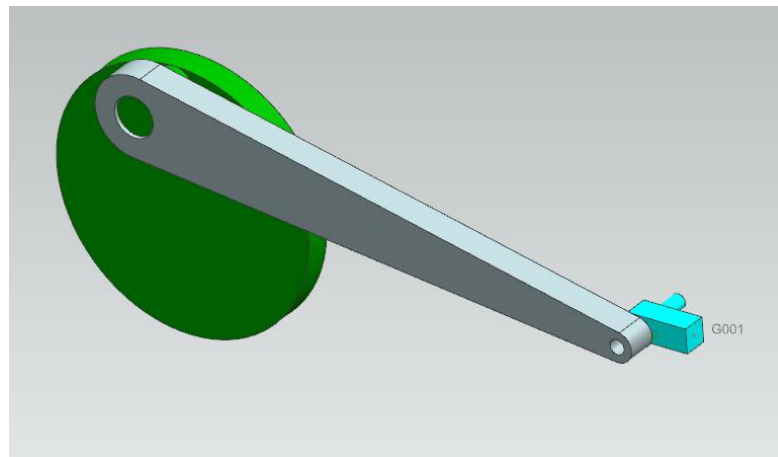## **Final Exam**
CAE part
Variant: 5

Flywheel acceleration
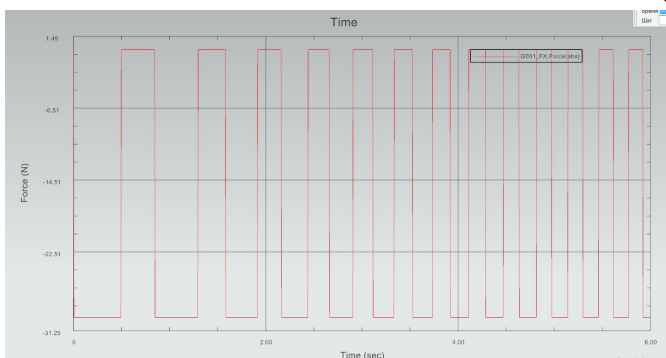
Input data description:
Create a geometric model of a simple mechanism (fig. 5a) that simulates the acceleration of the green flywheel by the force applied to the blue piston. Combined weight of the wheel and connecting rod of about 30 to 40 kg.
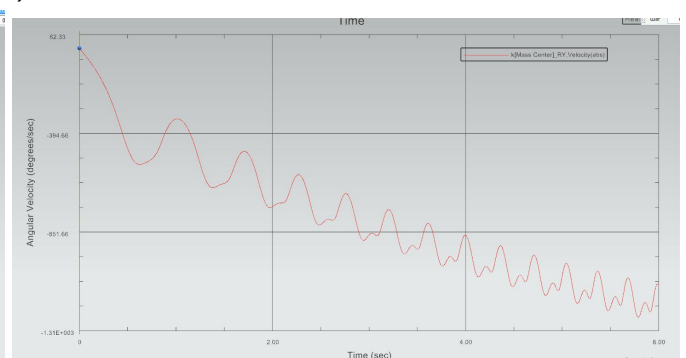
Task description description:

- For accelerating the flywheel, you should apply the periodic force (fig. 5b). The magnitude of the force is 30 N.

- Plot the graphs of the applied force (fig. 5b) and the angular velocity of the spinning wheel (fig. 5c).


(a)

(b)

(c)

# Monotonous pendulum stopping

Input data description:
Construct a simple geometric model of the pendulum shown below (fig. 6a). The mass of the red pendulum is approximately 1.5 - 2 kg.

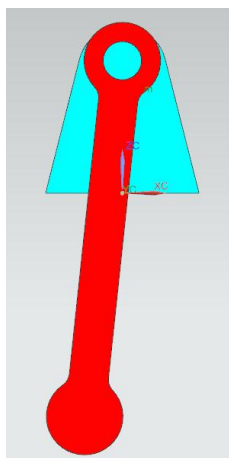**Task description description**:

- Apply a monotonically acting force to the pendulum in such a way as to completely restrict its center of mass from entering the negative XC region. Thus, the position of the pendulum shown in fig. 6b is considered to be completely unacceptable. To sum up, the force must constantly throw the pendulum to the right every time it reaches its vertical state. Its maximum possible entry into the negative XC region is shown in fig. 6c.

- The applied force must be described by a special function. fig. 6d shows a graph of a possible monotonic force.

- Change the magnitude of the applied force from 10N to 110N. Show how this affects how much the pendulum goes into the negative XC region, and the length of time that the monotonic force will act (fig. 6d).
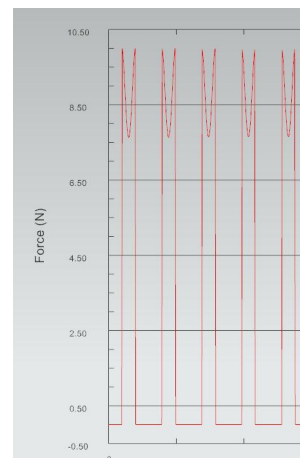

(a)

(b)

(c)

(d)
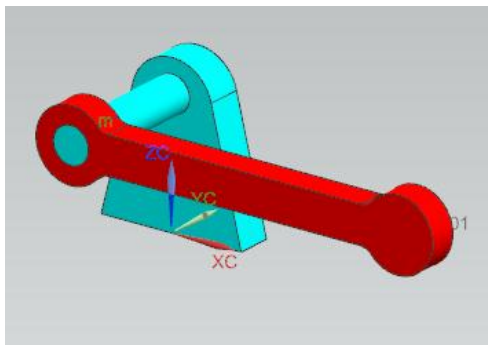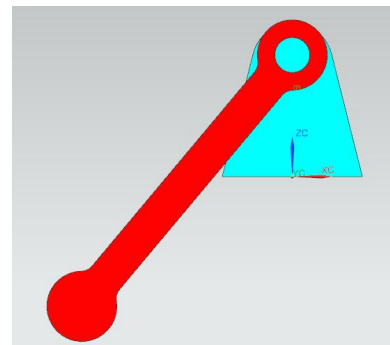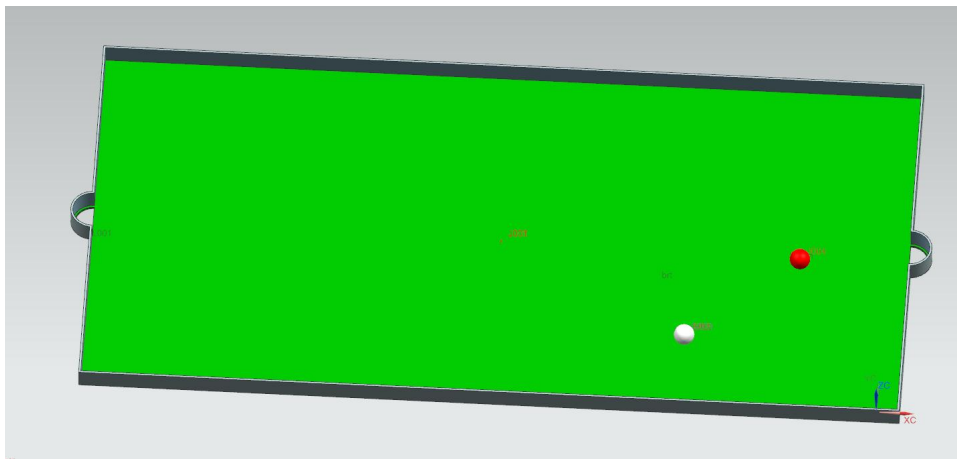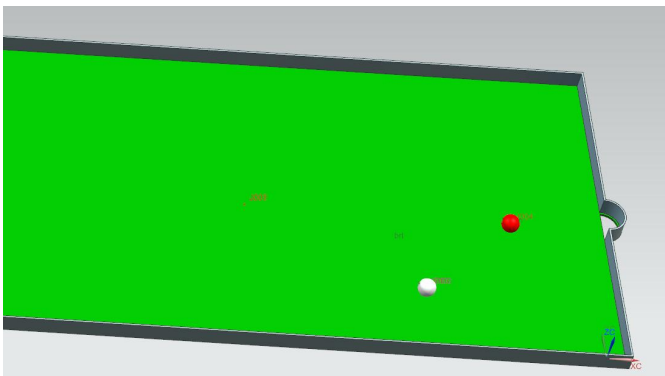
Billiards

Input data description:
Create a geometric model of a billiard table with two balls on it (fig. 7a). The mass of the balls is approximately 500 g. The analysis time is 1 sec.
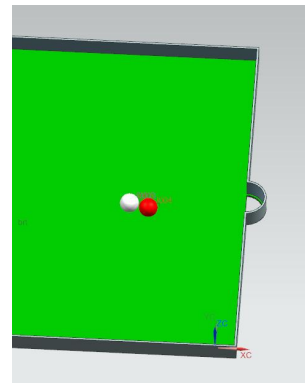**Task description description**: You should make that white ball hits a red ball, the latter hits the pocket (figs. 7b to 7e). It should be a tangential hit. It is impulse force.
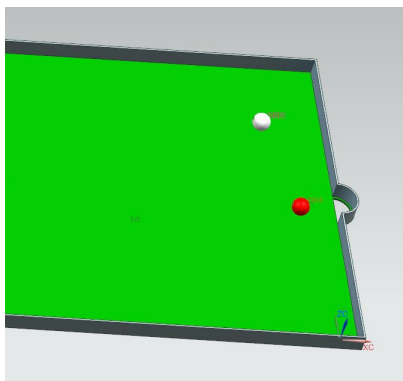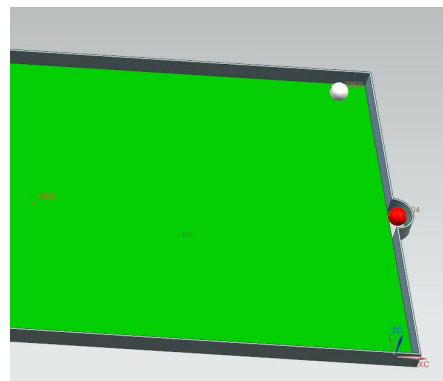

(a)

(b)

(c)

(d)

(e)

# Spring clamp

Input data description:

Construct a geometrical model of the simple mechanism shown in figs. 8a and 8b. - The idea of the mechanism is that the blue platform under the action of the applied momentum begins to rotate around the fixed gray base. The speed of rotation gradually increases. The green cross, is connected to the blue platform by a kinematic pair of the Slider type. The green cross is connected to the gray base by two red spring-loaded brackets (rotary joints, fig. 8b).

The parameters are following:

- Green cross weight: 10 kg.

- Set the applied torque so that the angular rotation speed of the blue platform around the gray base increases in about 1 second from 0 to 2 revolute per sec.

- Elasticity coefficient of the springs is 20 N/mm.
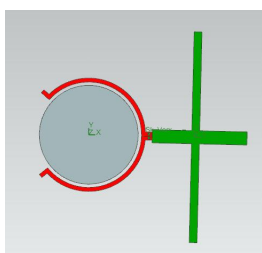
Task description description:

- Under the action of centrifugal force the green cross is gradually detached from the gray base (figs. 8c to 8g). Analyze the process of detachment. Plot the angular velocity of the blue platform.

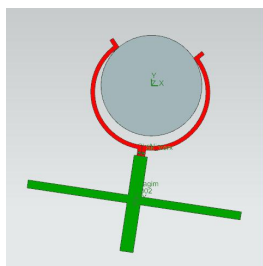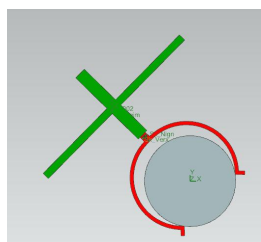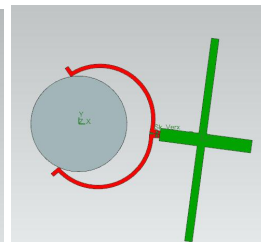- Plot the change in the distance between the ends of the red staples.
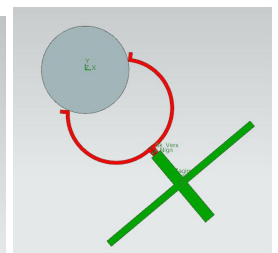

(a)

(b)
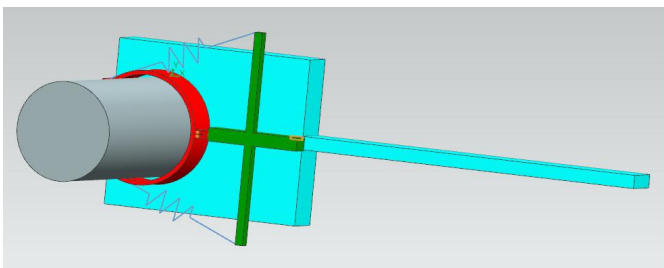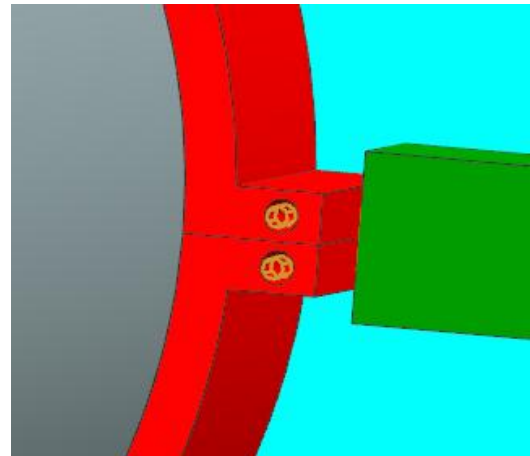
(c)   (d)   (e)   (f)   (g)
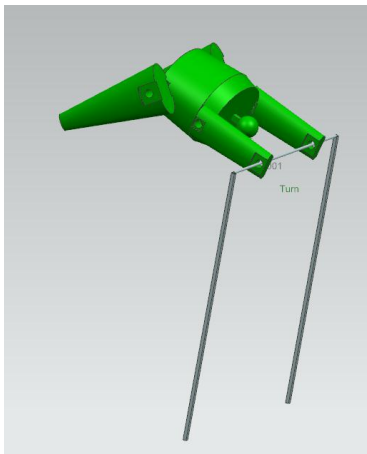
Final Exam
CAE part
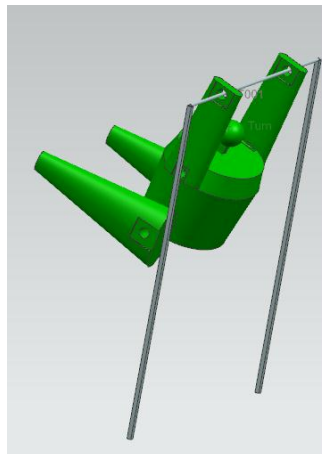## Variant: 9

Gymnast

Input data description:
Construct a geometric model of the system: the person on the bar. Make sure that the masses of individual parts of the human body are real (torso - 80 kg, arm - 7 kg, leg - 14 kg, etc.). The initial position is almost horizontal to the ground (fig. 9a).
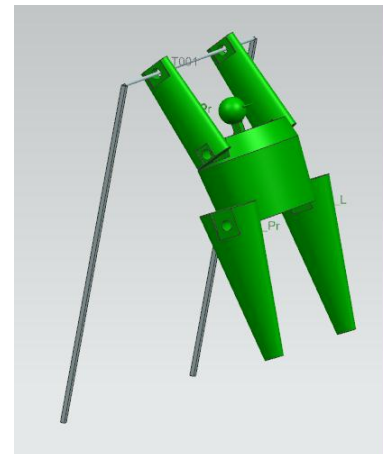
Task description description:

- At first, simulate the free swing of the "gymnast" only under the action of your own weight.

- Then select the amount of additional torque the "gymnast" must generate in order to make a complete turn around the bar (figs. 9a to 9e).

- The amount of torque should be applied only during the first half stroke (fig. 9f).
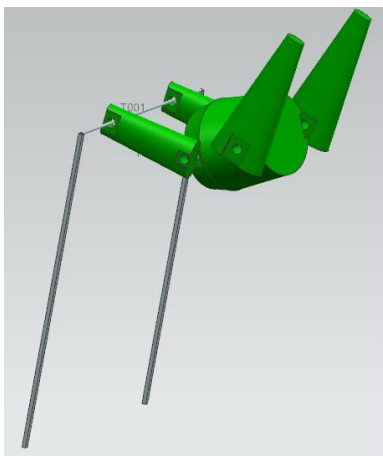
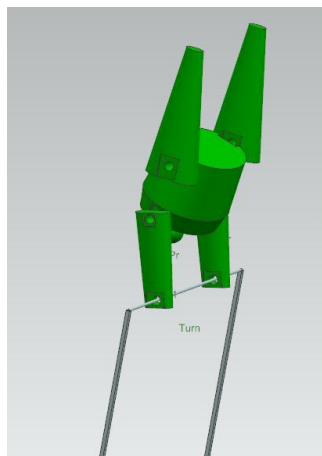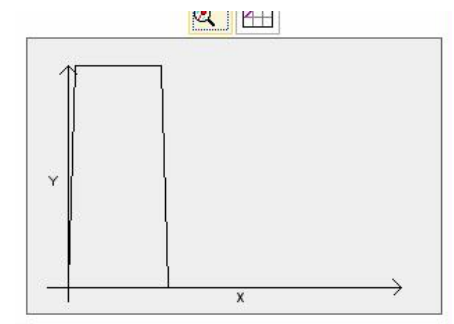- Plot the angular velocity of the "gymnast".

(a)

(b)

(c)

(d)

(e)

(f)

Backflip

Input data description:
Construct a geometric model of the system: a man on a uneven surface (fig. 10a). Make sure that the masses of individual parts of the human body are real (torso - 80 kg, arm - 7 kg, leg - 14 kg, etc.). Initial position is to be ready to do a backflip (fig. 10a).
Task description description:

- Use a combination of forces and torques acting for a short time (fig. 10g) on the "gymnast" to simulate his attempt to do a backflip (figs. 10a to 10f).

(a)

(b)

(c)

(d)

(e)

(f)

(g)