

Министерство науки и высшего образования Российской Федерации
федеральное государственное автономное образовательное учреждение
высшего образования
«НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ УНИВЕРСИТЕТ
ИТМО»

Отчет
по практической работе № 3
по дисциплине «Имитационное моделирование робототехнических систем»

Автор: Михин Н. С.
Факультет: СУиР
Группа: Р4150
Вариант (ИСУ) № 335259
Преподаватель: Ракшин Е. А.

ИТМО

Санкт-Петербург, 2025

Условия варианта:

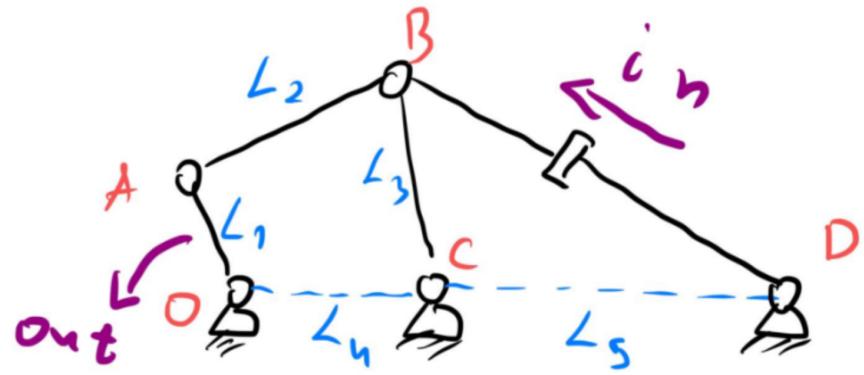


Рисунок 1 - OPTIMUS

$$L_1 = 0.074$$

$$L_2 = 0.0962$$

$$L_3 = 0.111$$

$$L_4 = 0.074$$

$$L_5 = 0.37$$

Ход работы:

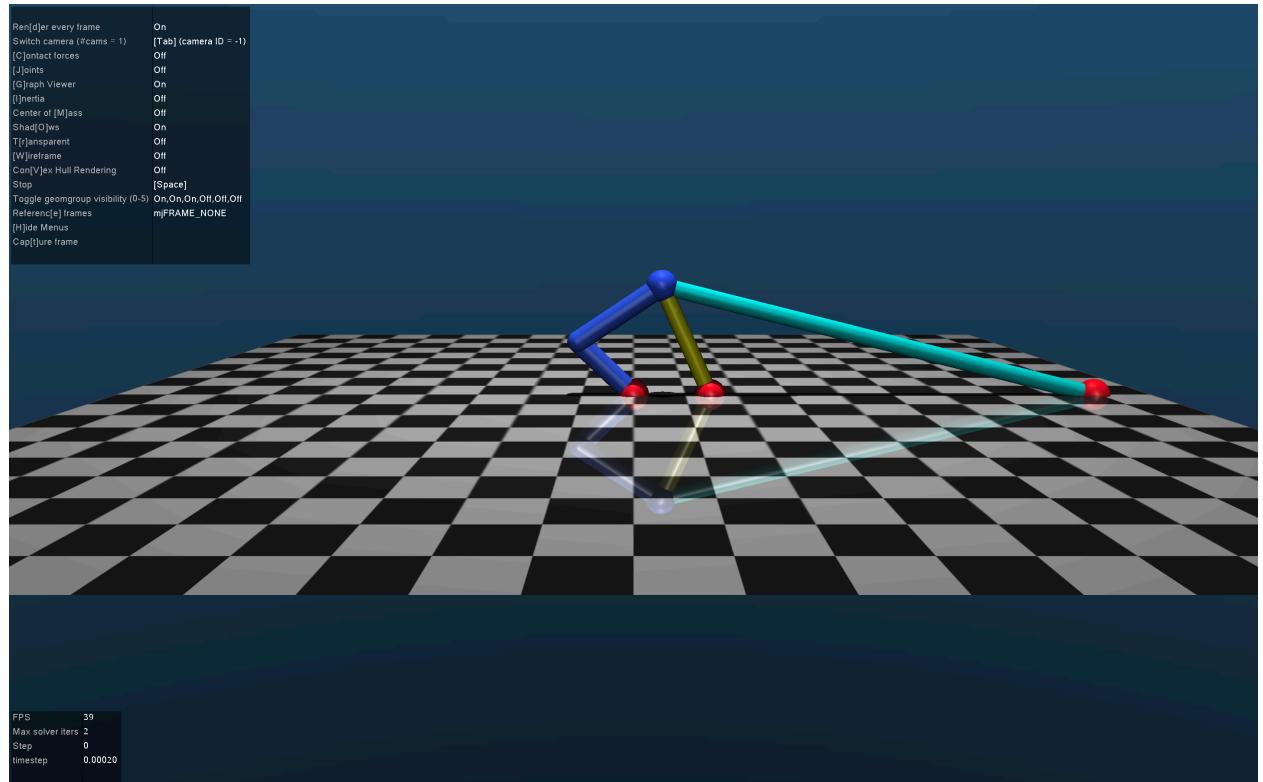


Рисунок 2 - Первое положение

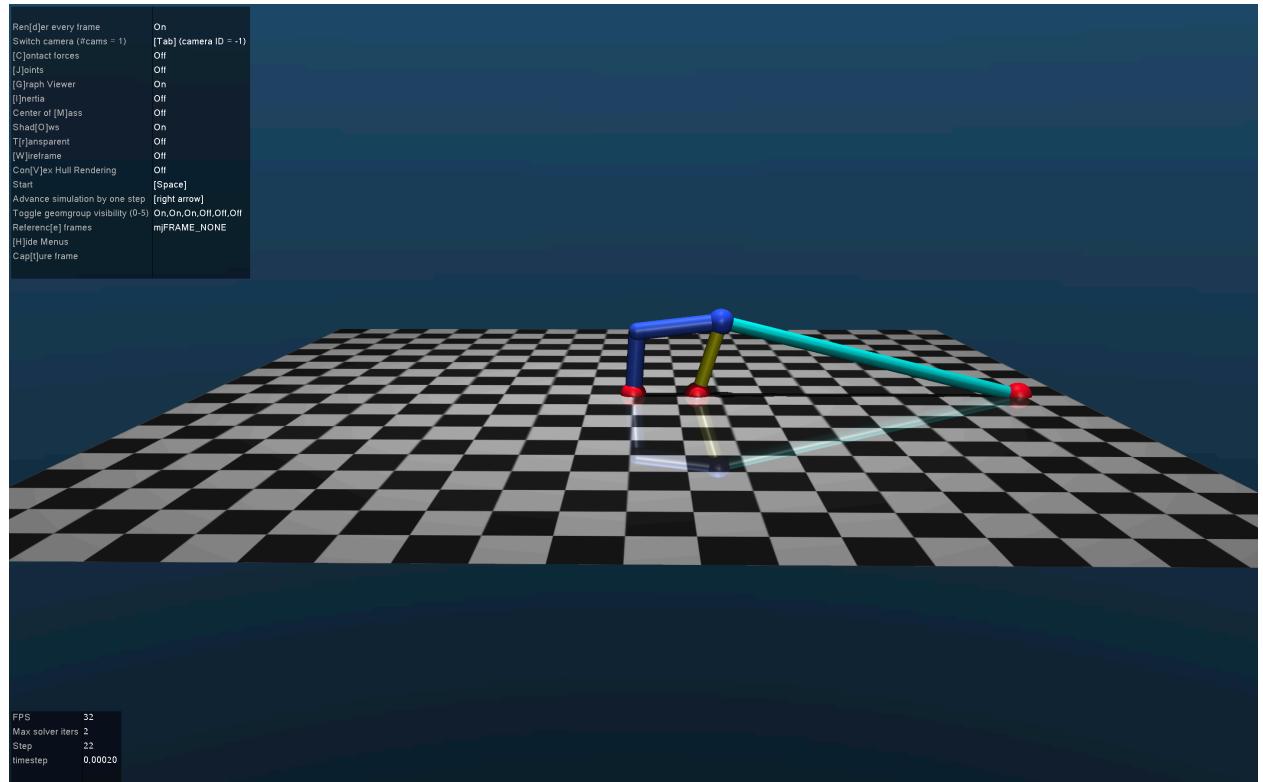


Рисунок 3 - Второе положение

Листинг 1 - XML модели

```
<?xml version="1.0" encoding="UTF-8"?>
<mujoco model="optimus_knee">
    <compiler angle="radian" inertiafromgeom="true"/>

    <option integrator="RK4" timestep="0.0002" gravity="0 0 0"/>

    <visual>
        <map znear="0.01" zfar="50"/>
        <rgba haze="0.15 0.25 0.35 1"/>
    </visual>

    <asset>
        <texture type="skybox" builtin="gradient"
            rgb1="0.3 0.5 0.7" rgb2="0 0 0"
            width="320" height="320"/>
        <texture name="grid" type="2d" builtin="checker"
            rgb1="0.1 0.1 0.1" rgb2="0.6 0.6 0.6"
            width="300" height="300"/>
        <material name="grid" texture="grid"
            texrepeat="10 10" reflectance="0.2"/>
    </asset>

    <worldbody>
        <light pos="0 0 2" dir="0 0 -1" diffuse="1 1 1"/>
        <geom name="ground" type="plane" size="0.5 0.5 0.1"
material="grid"/>

        <site name="site_O" pos="0 0 0" size="0.015" rgba="0.9 0.2 0.2
1"/>
        <site name="site_C" pos="0.074 0 0" size="0.015" rgba="0.9 0.2 0.2
1"/>
        <site name="site_D" pos="0.444 0 0" size="0.015" rgba="0.9 0.2 0.2
1"/>

        <body name="L1_body" pos="0 0 0">
            <inertial pos="0 0 0.037" mass="0.2"
                diaginertia="0.01 0.01 0.001"/>
            <joint name="J_O" type="hinge" axis="0 1 0"
                limited="true" range="-2.5 2.5"/>
            <geom name="G_L1" type="capsule"
                fromto="0 0 0 -0.0142133 0 0.0726222"
                size="0.01" rgba="0.21 0.32 0.82 0.9"/>
        </body>

        <body name="L2_body" pos="-0.0142133 0 0.0726222">
            <inertial pos="0 0 0.0481" mass="0.2"
                diaginertia="0.01 0.01 0.001"/>
            <joint name="J_A" type="hinge" axis="0 1 0"
                limited="true" range="-2.5 2.5"/>
            <geom name="G_L2" type="capsule"
                fromto="0 0 0 0.0882133 0 0.0383778"
                size="0.01" rgba="0.21 0.32 0.82 0.9"/>
        </body>

        <body name="B_body" pos="0.0882133 0 0.0383778">
            <site name="site_B" pos="0 0 0"
                size="0.015" rgba="0.2 0.3 0.9 1"/>
        </body>
    </worldbody>
</mujoco>
```

```
        </body>
    </body>
</worldbody>

<tendon>
    <spatial name="tendon_BC" width="0.008"
        rgba="0.8 0.8 0.2 1"
        stiffness="200.0"
        damping="2.0"
        springlength="0.111">
        <site site="site_B"/>
        <site site="site_C"/>
    </spatial>

    <spatial name="tendon_BD" width="0.008"
        rgba="0.2 0.8 0.8 1"
        limited="true" range="0.40 0.52">
        <site site="site_B"/>
        <site site="site_D"/>
    </spatial>
</tendon>

<actuator>
    <position name="actuator_BD"
        tendon="tendon_BD"
        kp="500.0"/>
</actuator>
</mujoco>
```

Листинг 2 - Код для моделирования

```
import os

import time
import mujoco
import mujoco_viewer
import numpy as np

base_dir =
"/Users/nikita/Documents/Учеба/ИМРС/симроубс_group_2025/SRS/practice_3/submissions"
xml_path = os.path.join(base_dir, "335259_MikhinNikita_Task3",
"optimus.xml")

print("XML path:", xml_path)

model = mujoco.MjModel.from_xml_path(xml_path)
data = mujoco.MjData(model)

print("nq =", model.nq, " nv =", model.nv)

data.qpos[:] = 0.0

if model.nq >= 3:
    data.qpos[0] = np.deg2rad(-35.0)
    data.qpos[1] = np.deg2rad(25.0)
    data.qpos[2] = np.deg2rad(-10.0)
elif model.nq >= 2:
    data.qpos[0] = np.deg2rad(-35.0)
    data.qpos[1] = np.deg2rad(25.0)

mujoco.mj_forward(model, data)

SIMEND = 10.0
Timestep = 0.001
STEP_NUM = int(SIMEND / Timestep)
times = np.linspace(0, SIMEND, STEP_NUM)

try:
    knee_site_id = mujoco.mj_name2id(
        model, mujoco.mjtObj.mjOBJ_SITE, "sB")
)
    if knee_site_id < 0:
        raise ValueError("site 'sB' not found")
except Exception as e:
    print("WARNING:", e)
    knee_site_id = None

knee_x = []
knee_z = []

viewer = mujoco_viewer.MujocoViewer(
    model,
    data,
    title="Optimus knee mechanism",
    width=1280,
    height=720,
)
```

```

RUN_SIM = True

for i in range(STEP_NUM):
    if not viewer.is_alive:
        break

    if RUN_SIM:
        time.sleep(0.01)
        mujoco.mj_step(model, data)

    if knee_site_id is not None:
        pos_knee = data.site_xpos[knee_site_id]
        knee_x.append(pos_knee[0])
        knee_z.append(pos_knee[2])

    viewer.render()

viewer.close()

mid = STEP_NUM // 2

def model_fn():
    return mujoco.MjModel.from_xml_path(xml_path)

def data_fn(m: mujoco.MjModel) -> mujoco.MjData:
    d = mujoco.MjData(m)
    d.qpos[:] = 0.0
    if m.nq >= 3:
        d.qpos[0] = np.deg2rad(-35.0)
        d.qpos[1] = np.deg2rad(25.0)
        d.qpos[2] = np.deg2rad(-10.0)
    elif m.nq >= 2:
        d.qpos[0] = np.deg2rad(-35.0)
        d.qpos[1] = np.deg2rad(25.0)
    mujoco.mj_forward(m, d)
    return d

def viewer_fn(m: mujoco.MjModel,
             d: mujoco.MjData,
             sim_time: float = 5.0,
             dt: float = 0.001,
             run_sim: bool = True,
             title: str = "Optimus - viewer_fn"):
    steps = int(sim_time / dt)
    v = mujoco_viewer.MujocoViewer(m, d, title=title)
    for _ in range(steps):
        if not v.is_alive:
            break
        if run_sim:
            mujoco.mj_step(m, d)
            v.render()
    v.close()

```