Homework 17 – Dynamics & computation/simulation MIPSI project. (Chapters 20, 24, 25)

The objective of a **MIPSI** is to ask and answer a question for a system of your own choosing.
The **2-3** page report **clearly communicates** its question, technical information, and answer.[1]
Attach multi-page appendix with all computer files (symbolic/numeric) and supporting calculations and figures.

- **Question** Ask an interesting dynamics question e.g., in biology (exercise, muscle activation, nature), mechanics (vehicles, boat, swing, yo-yo, home appliances, pump, motor), aerospace (aircraft, helicopter, balloon).

- **Model.** Draw one or more sketches. Use engineering insight to determine the relevant system components and simplify the model. Report modeling assumptions/approximations for:

Physical objects	(particles, rigid bodies, flexible beams, etc.)
Connections/constraints	(ideal pin joint, ball-and-socket, revolute motor, rolling, closed-chains, bearings)
Actuation/forces	(gravity, friction, springs/dampers, muscles, aerodynamic forces, elasticity)

  Type a **short** problem statement (mimic format in Chapter 25) starting with "The following figure shows", and then describe all objects. Ensure all physical objects are clearly labeled on sketches and described in text (e.g., name and label airplane A, book B, point P, etc).

- **Identifiers (symbols and values).** Describe all relevant **unit vectors** with both text and sketches (sketches of right-handed orthogonal unit vectors only need to show two of the three unit vectors).

  Include a table of relevant scalar identifiers with four columns labeled:

Quantity	Identifier	Type	Value

  (**estimate** numbers for constants and initial values).
  Show relevant scalar identifiers on the sketch(es) without clutter.

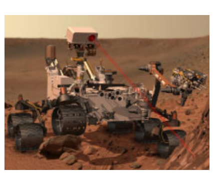
- **Physics.** Form equations relating the identifiers to system behavior. Highlight complex processes. Attach long calculations and MATLAB®/**M**otion**G**enesis codes in an appendix, e.g., to:
  - Determine the mass of particles/bodies and moments/products of inertia of rigid bodies
  - Calculate rotation matrices, angular velocities, and angular accelerations
  - Calculate positions, velocities, and accelerations (e.g., points, particles, and body mass centers)
  - Calculate/add relevant contact and distance forces (or torques)
  - Form relevant **equations of motion** (forces and motion)

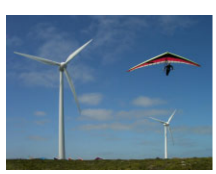
- **Simplify and Solve.** If helpful, make small angle or linear approximations [e.g., $\sin(\theta) \approx \theta$]. Discuss the process for solving for the unknown identifiers [e.g., numerical solution via **M**otion**G**enesis, MATLAB®, or WolframAlpha or analytical (closed-form) solutions].

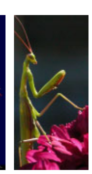
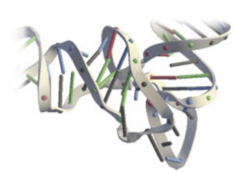
- **Interpret** **(design and control).** Answer your question with results easily interpreted by a non-technical person (use words, numbers, plots, video, etc., with descriptive text **adjacent** each plot).
  Optional: Build the physical system, validate the analysis, physical demonstration, video.

	10%	**Cover-page**: Ask, answer, and present (question, system picture, team picture, result).
Model	15%	Detailed modeling assumptions and comprehensible schematics (preferably with photo). Precise description of all physical objects and unit vectors.
Identifiers	10%	Concise accurate tabular description of all **scalar** symbols.
Physics	10%	Correct MG road-map or high-level summary of calculations.
Simplify and solve	30%	Correctness of analysis. **Short (2-3 pg.)**, solid report. Appendix of calculations.
Interpret and design	15%	Interpret: Relevant text interspersed with relevant plots.
	10%	On-schedule. Met with instructor. Technical difficulty, demo/video, interesting problem.

Communicate!



[1]For ideas, see videos at www.MotionGenesis.com ⇒ Textbooks ⇒ Resources or www.YouTube.com.

Ideas and previous MIPSI projects

Badminton flight with shuttlecock reversal.	Longitudinal stability of aircraft flight (phugoid mode).
Precession and nutation of spinning gyro .	Trajectory and orientation of a punted football (2D/3D) (effect of air-resistance and initial spin).
Translation and rotation of skateboard on 2D curve.	Function of the soleus muscle during calf raise.
Pendulum connected by a revolute joint (with/without viscous friction) to a point moving in horizontal or vertical slot with specified displacement $A \sin(\Omega t)$.	Tuned oscillation of two particle pendulums (moving in 2D plane) connected mid-rope by massless rigid rod (analyzed with 3 angles).
Statics/dynamics of equilibrium inclination angle θ of Chair-O-Planes (amusement-ride swing carousel).	Static and dynamic analysis that determines equilibrium inclination angle of amusement-ride swing.
Time-variation of G-force in tea-cup amusement ride.	Dynamics and control of telescope tracking a comet.
Effect of children's pumping frequency on a playground swing's amplitude.	Effect of Earth's spin on a ball dropped from a tower at the equator.
Effect of Earth's spin on a baseball-pitch.	Motion of a pitched curve-ball.
Effect of viscous and aerodynamic damping on a pendulum's amplitude and frequency.	Foucault's pendulum for various locations on Earth.
Bobbing frequency of partially submerged ship, iceberg.	Hip muscle tension for hip flexion.
Flight of a tennis-ball that is connected to a long stretching rubber band that is initially slack.	Spring/mass/damper motion of Tower of terror on passenger acceleration-g (similar to elevator whose cable is cut)
Effect of column stiffness/damping on a single or double-story building in an earthquake.	Effect of tuned damper on the motion of a single-story building in an earthquake.
Dynamics and control of overhead crane.	Input shaping and slewing maneuver for an overhead crane carrying a Boeing aircraft.
Motion of hockey-puck on a spinning playground carousel.	Location of a rider on teacup/other amusement ride.
Effect of deployment of solar panels on spacecraft spin (similar to ice-skater pulling in arms).	Stability of satellite deployment/retrieval from geo-synchronous space-shuttle in Low Earth Orbit.
Satellite orientation control through control-moment gyros.	Particle motion with slight perturbation from geo-synchronous orbit as viewed from Earth or in spacecraft.
Effect on satellite spin-stability from gyros aligned with principal inertia axis.	Dynamics and control of a rocket launch (2D/3D).
Dynamic simulation of the relationship between area traced out by orbiting object and time (Kepler's law).	Optimal orbit transfer (Hohmann orbit transfer).
Muscle activation during a pushup or pullup.	Effect of mass distribution or feet-elevation on required muscle forces during a pushup.
Trajectory of a homerun or stomp-rocket (with and without air-resistance).	Effect of mass distribution or feet-elevation on required muscle forces during a pushup.
Effect of friction and geometry difficulties of a particle sliding on an wire in a vertical plane shaped like an ellipse.	Period of motion of particle sliding on an circular (or elliptical) wire in a vertical plane connected to the circle's center by an ideal spring.
Dynamic simulation of a tippe-top or spun-football that turns upright.	Dynamic simulation of the spin-reversal of a rattleback.
Dynamic simulation of a slipping/rolling bowling ball with or without holes.	Effect of the specified motion associated with kicking a soccer ball (football) on knee reaction forces.
The path painted on a horizontal plane of a rolling sharp-edged disk (wheel).	Dynamics and control of a hula-hoop or "German Wheel".
Dynamics and control of camera tracking a ball in a stadium.	Position, velocity, and acceleration determination from 3 lasers measuring distance, elongation, and elongation-rate.
GPS or other system position and orientation determination of rigid bodies.	Parachutist in free-fall before/after parachute deployment with/without side-wind.
Effect of center of mass on frequency of a rocking sailboat.	Effect of gyros on stability and sea-sickness for cruise-ship.