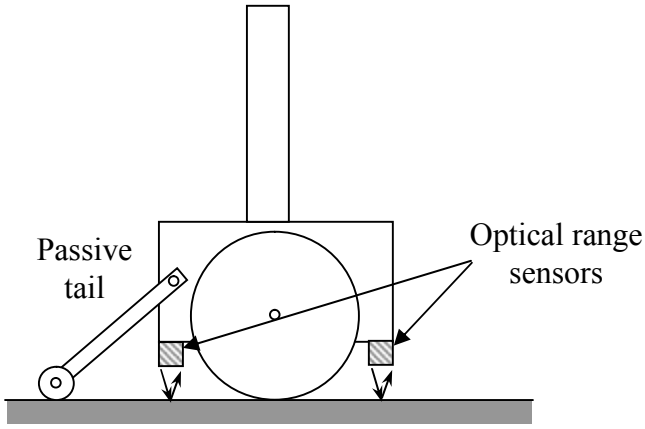
Project 1

The goal of the first project in this course is to design and build a self-balancing wheeled mobile robot.

Option 1:
In this project a (statically stable) 4-wheel vehicle is to be designed and built. An inverted pendulum is to be mounted on the vehicle (using a passive hinge). The goal is to feedback the angular position of the inverted pendulum (using a potentiometer) and to control the vehicle's movements in such a way as to maintain the pendulum in the vertical position (classic inverted pendulum balancing problem).
The cart is expected to maintain pendulum's vertical posture while moving between 2 points nearly 3 meters apart. The cart should have a suitable locomotion system with enough power, enabling it to perform the above tasks in both forward and reverse motion. In other words the system is expected to behave symmetrically in both forward and reverse direction.

Option 2:
In this project a (statically unstable) 2-wheel vehicle is to be designed and built. The two wheel vehicle and the structure mounted on top of it will act like an inverted pendulum. The goal is to feedback the angular position and/or velocity of the structure (using a gyro and/or tilt sensors) to control the vehicle's movements in such a way as to maintain the vehicle in the vertical position.



The robot is expected to maintain its nearly vertical posture while moving between 2 points nearly 3 meters apart. The robot should have a suitable locomotion system with enough power, enabling it to perform the above tasks in both forward and reverse motion. In other words the robot is expected to behave symmetrically in both forward and reverse direction.
Note: An inexpensive method of measuring the tilt angle is to use one the two techniques
a) Use optical sensors to measure the distance between the vehicle and floor at two different points (one on the front and one on the back side of the vehicle)…see figure
b) Use a potentiometer connected to a passive tail (see figure)

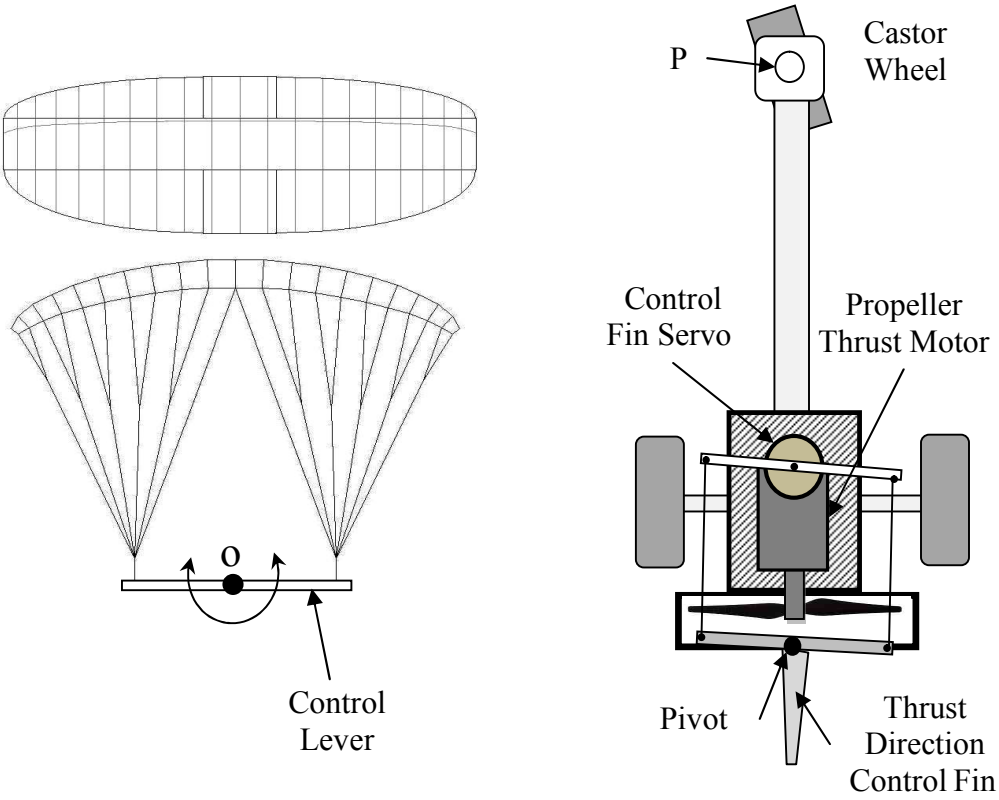
The robot must be able to operate without cues or input from the operator.

You can choose between option 1 and option 2.
Option 1 (a team of 2 persons): Maximum score 3 points+ 1 points bonus for achieving movements between two points while maintaining stable posture
Option 2 (a team of 3 persons): Maximum score 3 points + 1.5 points bonus for achieving movements between two points while maintaining stable posture.

Project 2

The goal of this project is to design and build a land-based tricycle model of a robotic paraglide or a hovercraft (both getting their thrust force from a propeller). In a paraglider, the pilot controls the lateral motion of the paraglider by rotating the control lever about point O and controls longitudinal motion by moving the control lever in and out of the plane. The motion in the longitudinal direction can also be controlled using the thrust force generated by the propeller.
In this project you have the option of building a robotic paraglider or a land-based tricycle model as shown. The tricycle uses a castor wheel (free to rotate about pivot P) in front and a fin for the thrust direction control in the back. The goal of the project is to design, build a prototype of this device and control its motion using a microcontroller/microprocessor. The device can operate with battery or powered by a cable. The control objectives are use a radio link to control the motion from a control panel or a joystick. One should be able to increase/decrease the propeller speed and change the angle of the control fin to move the device on a straight line, rotate right and left using commands from the control panel or the joystick.

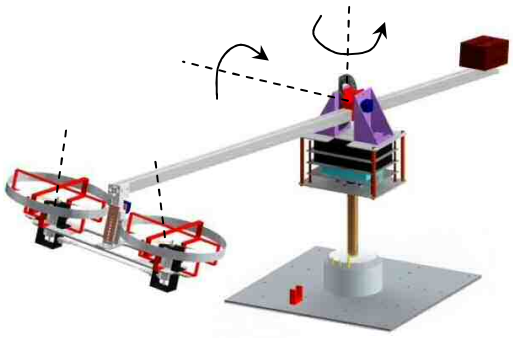
Option 1 (land based model ... a team of 2 persons): Maximum score 3 points + 1 points bonus for achieving controlled movements from the control panel/joystick with radio link
Option 2 (flying paraglider ... a team of 3 persons) Maximum score 3 points + 1.5 points bonus for achieving controlled movements from the control panel/joystick with radio link.



پروژه ۳

طراحی و ساخت یک سیمولاتور هلیکوپتر دو درجه آزادی

هدف در این پروژه ساخت یک سیمولاتور هلیکوپتر یا یک سیستم Quadrotor با قابلیت سیموله کردن حرکت pitch و حرکت طولی (یا Yaw) با استفاده از دو پروانه(با عملکرد جمعی/ تفاضلی) برای ایجاد حرکت دورانی pitch (حول محور افقی) و حرکت طولی (یا Yaw) (دوران حول محور قائم) می باشد. حرکات دورانی توسط دو پتانسیومتر اندازه گیری و با اعمال ورودی مناسب به هر یک از دو پروانه خواهد شد. سیستم طراحی شده باید بتواند تغییر ۱۰ درصدی موقعیت مرکز جرم را بدون مشکل تحمل نموده و قابلیت حفظ زاویه دلخواه pitch را در محدوده $\pm 15^{\circ}$ و yaw را در محدوده $\pm 90^{\circ}$ داشته باشد. این پروژه باید بصورت دو نفره انجام شود.



You will be provided with a mechanical kit and a set of sensors and DC / DC brushless motors whose specifications are given in a set of data sheets. You are free to select from the items provided in the kit or buy/purchase your own items which may not be provided to you, but are necessary for your design (at your own risk and cost).

You are responsible for any damage to the parts (i.e. DC motors / sensors / electronic boards ….etc.)

The report for the project should include the following sections:

1- Mechanical design and prototyping

In this part of the report you are expected to go through the steps listed below. The report provided should specifically address each of these steps:

1.a- Conceptual design stage: In this section a couple different possible designs for the robot wheel/drive configuration should be discussed and the necessary design constraints for the robot to achieve all the project requirements should be listed. Each design should include a possible placement for the electronics and sensors.

1.b- The computations/assumptions for longitudinal velocity and acceleration profiles during start/stop and traction forces necessary for proper operation

1.c- Actuator type / sizing and gear box selection: Based on the assumed velocity / acceleration profile and traction force computations (and assumed weights), the type and specifications for the different actuators in the robot should be obtained using the worst case analysis (i.e. output motor torque, gear ratio,…etc)

1.d- The computations/assumptions for the robot stability along the path and for the worst maneuver

1.e- The computations/assumptions/rationales' for the optimal location for the center of mass of the vehicle

1.f- Detail design and placement for all components (chassis, actuators, sensors and drive electronics, microcontroller board…etc). Use of Mechanical Desktop or Solid Works Software for this purpose is optional and has extra credit.

In your design and prototype you should leave enough space/room on the bottom, in the front or on the back to be able to add the necessary sensors to meet the "**sensory requirements**".

The design should also have enough room to place the microprocessor board as well.

2-Electronic/control design / Prototyping

In this part of the report you are expected to go through the steps listed below. The report provided should specifically address each of these steps:

2.a- Design for sensory system and electronic interfacing. The design should include the sensory requirements for the successful implementation of each of the proper operation. This should include:

1-Stating the necessity for the use of sensors (including type, range / resolution / accuracy,….etc and justification / rationalization for the sensor selection process)

2- Sensor drive / interface electronic circuitry

3- Schematics for the sensory subsystem (sensor + electronic interface circuits)

2.b- The sensory systems used for detecting tilt angle (for 2 wheel project)

2.c- Sensory interfacing to the microcontroller/microprocessor board (Which pin / ports are used on the microprocessor board and how the signal voltage level requirements are met)
2.d- Implementation of the voltage/current control on the main drive motors of the robot
2.e- Design a digital controller to stabilize /control the movement of the device
2.f- The algorithm / flowchart for the main program + Subroutines/functions ….etc.
2.g- The microprocessor/microcontroller program (including the main program and all the procedures , subroutines) with appropriate comments in the program (declaration of all variables ,….etc)

3- Hardware/software Implementation

At the end in addition to the report, you should turn in the assembled robot with all the necessary actuators, sensor and the electronic circuitry interfaced to the microcontroller board. The goal is to control the movement of the device while maintaining the stability and achieve the objectives defined on the project description page. Performance of the device will be evaluated based on

1) The ability to resist external destabilizing disturbance forces/torques
2) Its robustness to changes in the inertial characteristics (the change in the mass of the device or change in the inertia of the components in the system).
3) The transient response characteristic (oscillatory behavior or speed of response) and steady state error.

The hardware/software implementation:	50%
The report:	50%