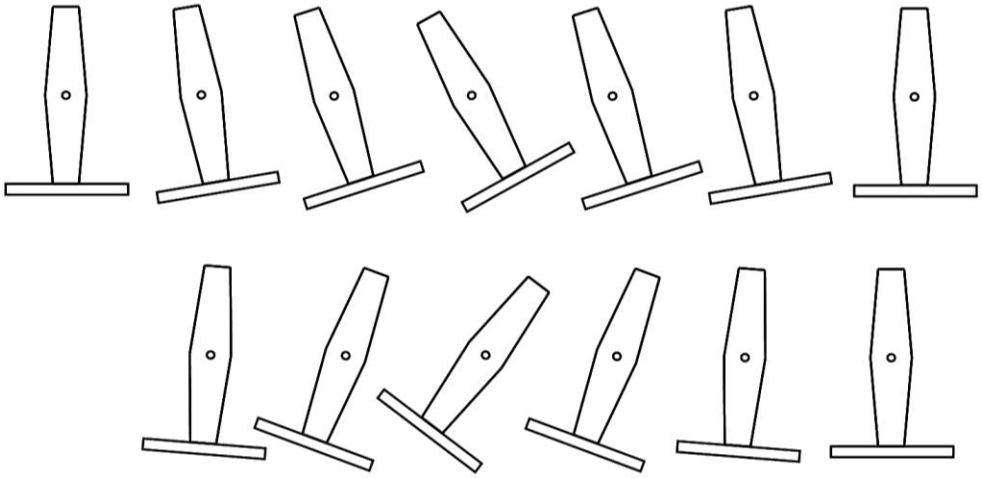
The Skymaster

The Model

The SkyMaster is rather like a pendulum. Give it a push and it will swing back and fro. Here's a sketch showing several steps in the oscillation. Note here the oscillation is a rotation, unlike the displacement of the monster truck.



The *amplitude* of the oscillation is the maximum amount of movement of the object, here rotation. For the above figure I guess it's around 15 degrees. The *period* of the oscillation is the time taken to complete one whole swing, from any starting angle back to that angle and back again (Think – what is a "whole swing"?). Without any friction or *damping* the SkyMaster will oscillate for ever, we need to include *damping*.

What makes the Syymaster move? Well, it's the guy in the control cabin. He's got a joystick so when he moves to the left and the Skymaster will get a push (an *impulse*) in a clockwise direction and when he moves it to the right the Skymaster will get an impulse in an anti-clockwise direction. So the operator can build up the amplitude of the oscillations by applying successive impulses, and of course send the Skymaster over the top.

In this project we shall replace the operator with a periodic drive. So the operator can specify the period of the drive (time for each cycle) and the amplitude of the drive.

The maths which governs the behaviour of the Skymaster is as follows. If you want to see how this is derived, look at the advanced Skymaster documentation. There are two parts to the maths. First is τ_m the torque on the ride due to the motor. This has amplitude A_d and period T_d

$$\tau_m = A_d \cos\left(\frac{2\pi t}{T_d}\right)$$

To get the total torque τ we add on the effect of gravity on the ride $-mg(Lsin\theta)$ and friction $-b\omega$ so we get

$$\tau = -mg(Lsin\theta) - b\omega + \tau_m$$

Possible Investigations

Use the default parameters from the following table.

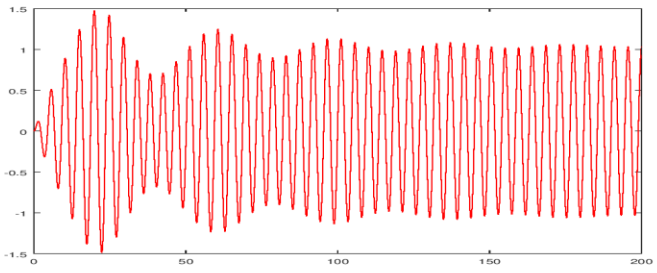
armLength	0.2824
mmass	1.0
gravity	9.8
armDamp	0.1
drivePeriod	1.0

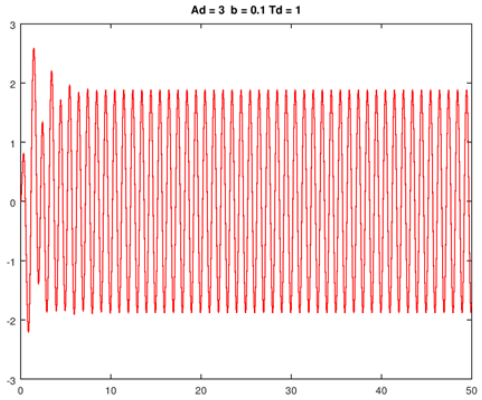
Change the **driveAmp** and record the **maximum angle**. The HUD will give you angles in 'radians' To convert to degrees, then multiply by 180 and divide by pi (3.141529) if you like, but not required. You could do this in your HUD code. Here's a table for your results

driveAmp	max angle
0.5	
1.0	
2.0	
…	
5.0	

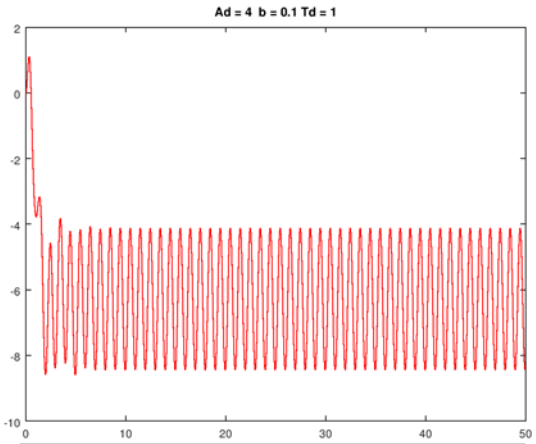
Try values of driveAmp from 0.5 to 5.5. You will find several **patterns** of behaviour, some I found are shown on the next page.

Be careful when you collect your data, it takes time for the Skymaster to settle into a rhythm. You can see this in the plot below, where there is an initial 'transient' where the amplitude wobbles before it settles down into a constant value.

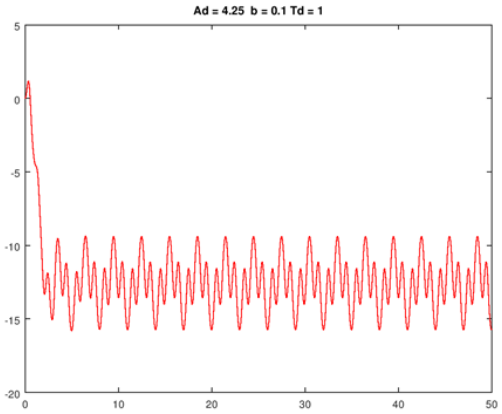




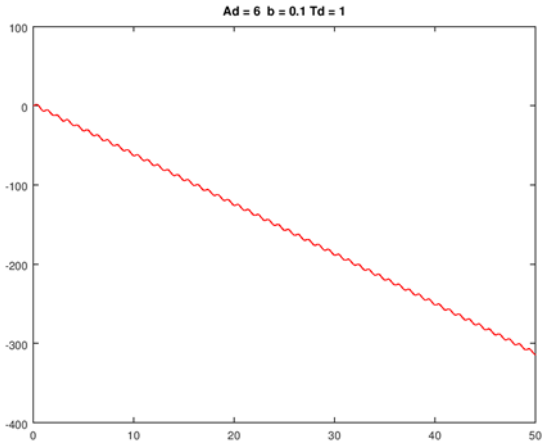
Simple result. The Skymaster oscillates with an amplitude just under 2.0 after an initial ‘transient’



The Skymaster rotates ‘over the top’ then settles down to nice oscillation



Very Very interesting. There are 3 cycles in each repeated motion. Stuff for “Phase 2”



Here it’s going over the top again and again, just rotating (with a bit of a wiggle)

So what should you do? Well, collect diagrams like the ones above, and see if you can find any pattern as you increase driveAmp as suggested above. To calculate the “max Angle” measure the difference between the top and bottom of the oscillation and divide by 2. E.g., for the top-right example the calculation (approx) is (-4 - -8)/2 = 4/2 = 2.