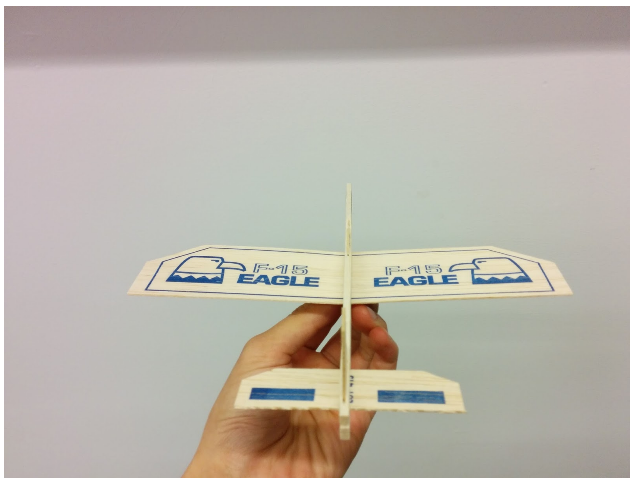
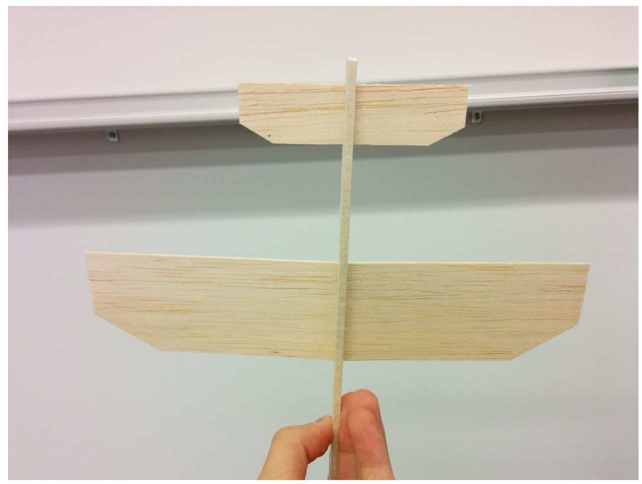
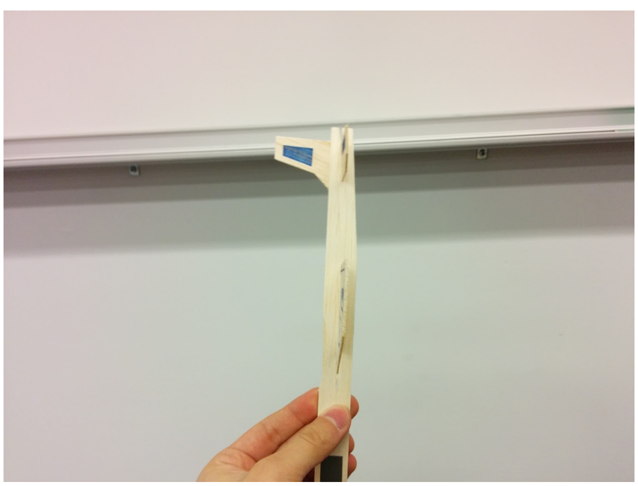
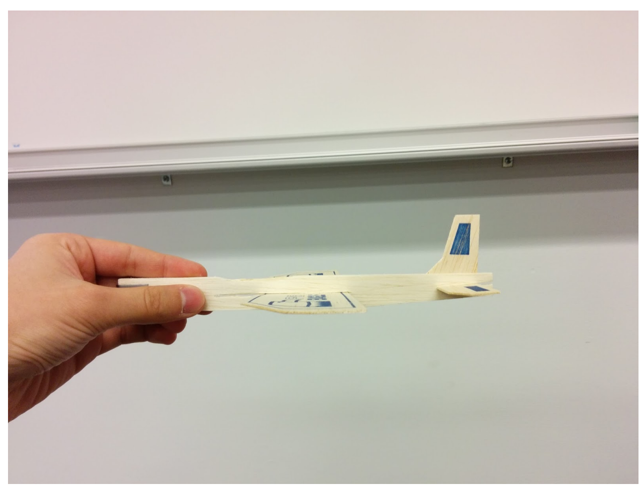
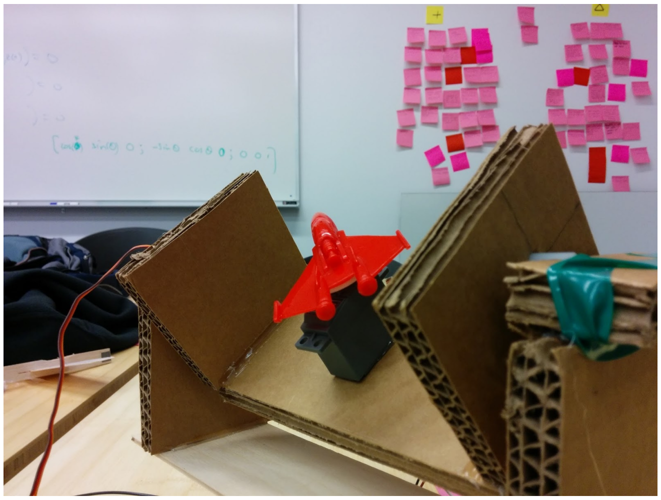
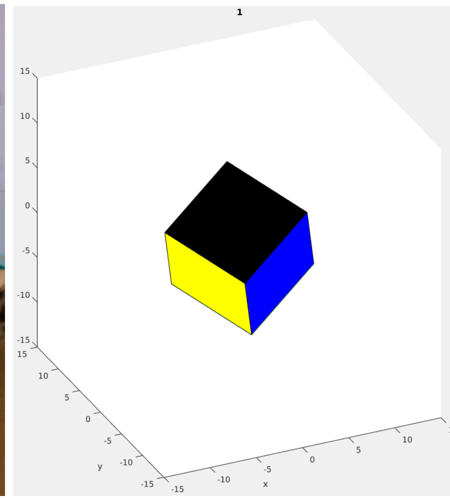
Nathan Yee
QEA - Bset1
Attitude Control

1. .
2. .
3. .
4. .
5. Below we have a grid orientations. To get from orientation 1 to 4, we have two possible routes. We can either do a single rotation from 1 to 4, or we can rotate 1 to 2, 2 to 3, and finally 3 to 4.

1 	2 
3 	4 

6. Here we see a plane and a cube rotated by 45, 45, and 45 degrees. We see that our plane and cube both experience the same rotations!





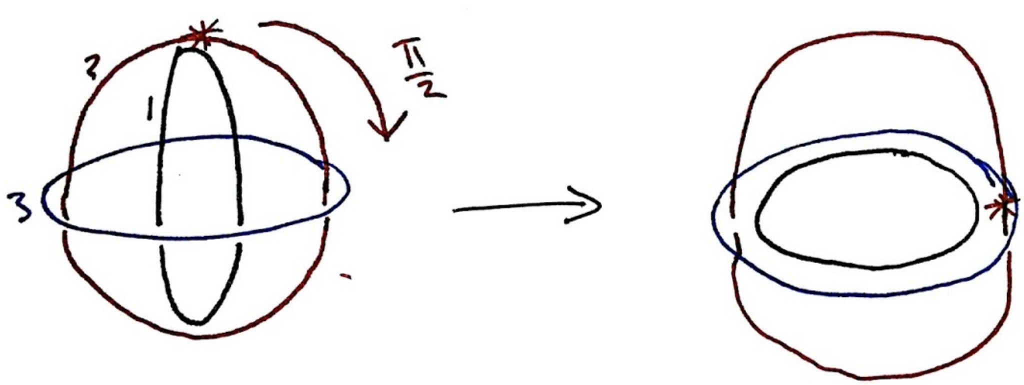
7. Optional assignment I didn't do.
8. Gimbal lock is the situation where two of three axes in a gimbal are on the same plane. This makes it impossible to rotate along the missing plane without moving in an infinitesimally offset arc.

8

Bset 1
Attitude

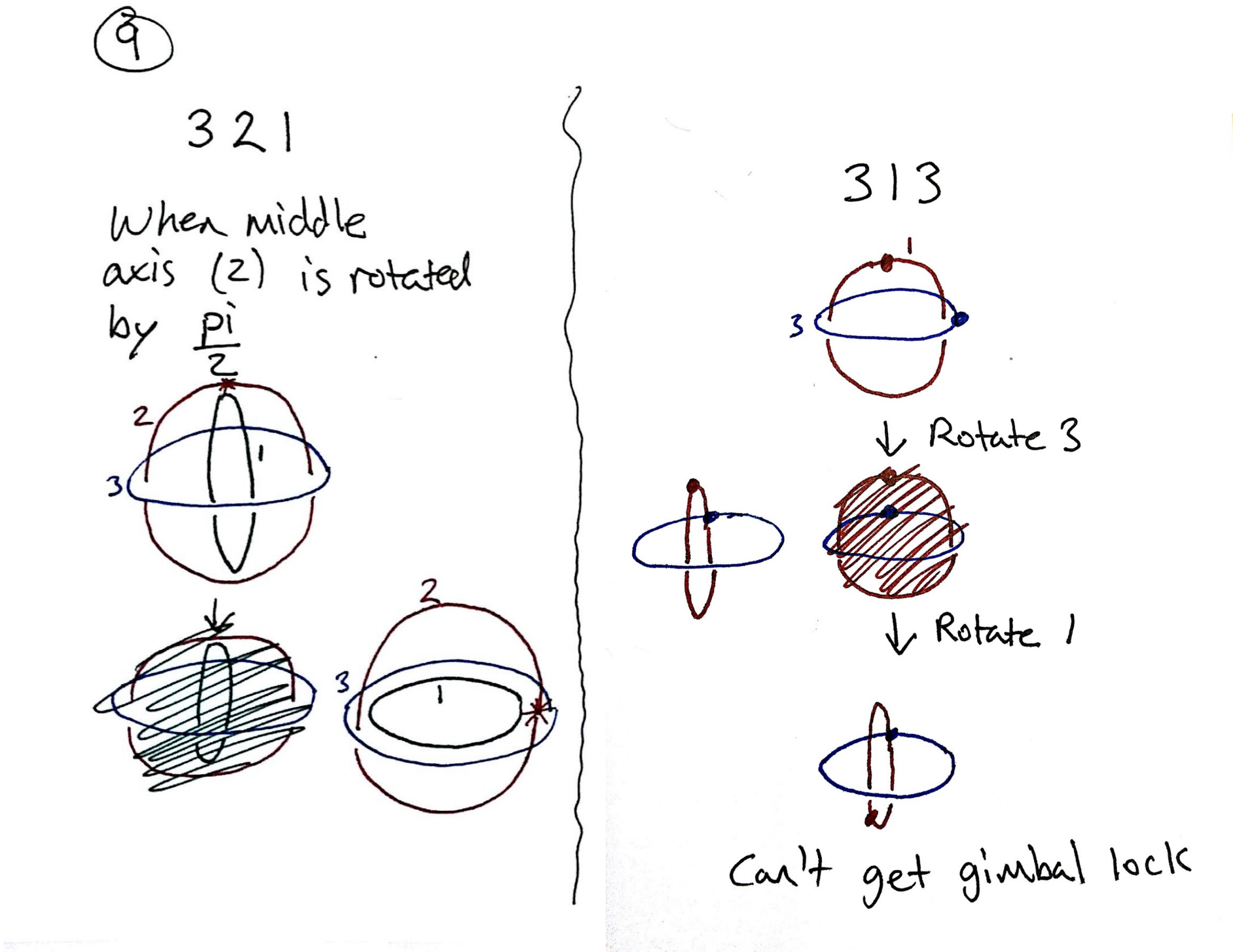
Unlocked gimbal

Locked gimbal

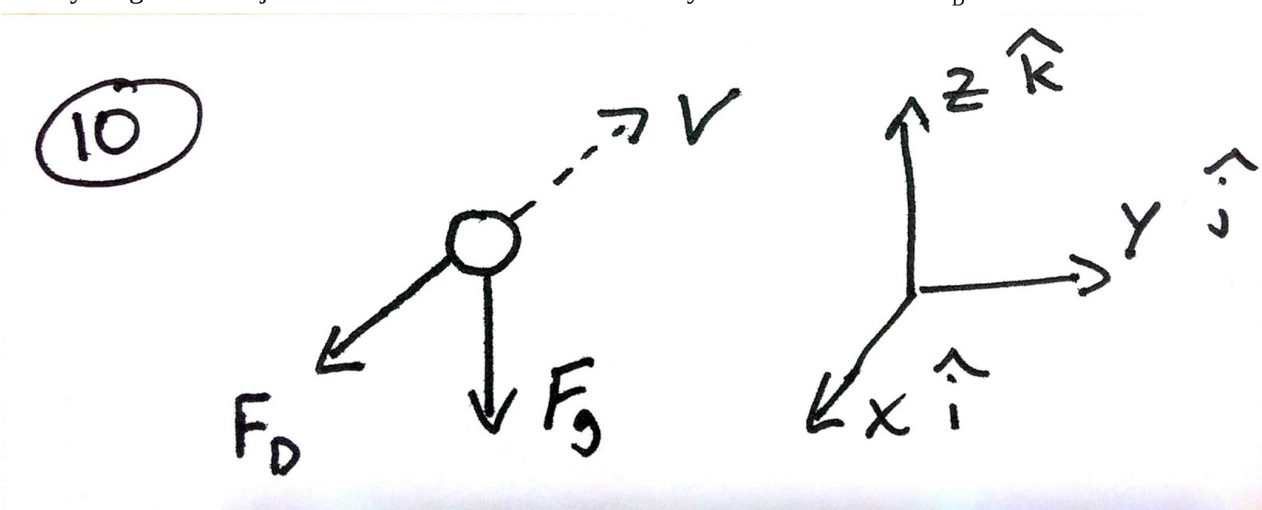


Rotating 2 allows us to get gimbal lock

9. Can’t get gimbal lock when we have a 3-1-3 system. We can get gimbal lock in a 3-2-1 by rotating the middle axis by Pi



10. Free body diagram of object. Wind is included in the velocity and takes effect in F_D.



11. Equation of sum of forces.

(11)

$$\Sigma F = ma = F_D + F_g$$

$$ma = -\frac{1}{2}\rho C_D \frac{\pi D^2}{4}\sqrt{(V_x-W_x)^2+(V_y-W_y)^2+(V_z-W_z)^2}\left((V_x-W_x)\hat{i}+(V_y-W_y)\hat{j}+(V_z-W_z)\hat{k}\right) - mg\hat{k}$$

12. Separated the variables. Interestingly, V contains the velocities of other speeds. I wasn't exactly sure how to handle this.

(12)

$$\cancel{\frac{d^2x}{dt^2} = -\frac{1}{2}\rho C_D \frac{\pi D^2}{4} V}$$

$$\frac{dx}{dt}$$

$$\frac{d^2x}{dt^2} = \frac{1}{m}\left(-\frac{1}{2}\right)\rho C_D \frac{\pi D^2}{4} V \, (V_x - W_x)\hat{i}$$

$$\frac{d^2y}{dt^2} = -\frac{1}{m}\frac{1}{2}\rho C_D \frac{\pi D^2}{4} V \, (V_y - W_y)\hat{j}$$

$$\frac{d^2z}{dt^2} = -\frac{1}{m}\frac{1}{2}\rho C_D \frac{\pi D^2}{4} V \, (V_z - W_z)\hat{k} - mg\hat{k}$$

13. Separated the 2nd order differential equation into two first order equations.

(13)

$$x'' = -\frac{1}{m}\frac{1}{2}\rho C_D \frac{\pi D^2}{4} V \, (x' - W_x)$$

$$x_1' = x'$$

$$x_1 = x$$

$$x_2 = x' = \boxed{x_1'}$$

$$\boxed{x_2'} = x''$$

$$\begin{cases} x_2' = -\frac{1}{m}\frac{1}{2}\rho C_D \frac{\pi D^2}{4} V \, (x_2 - W_x) \\ \underline{x_1' = x_2} \end{cases}$$

14. Work in progress. I am very close to getting this working. One of my lists is not behaving as I expect.
15. WIP

16. WIP
17. Yeah the third piece of location information seems to be missing. I'm not sure where it is. As far as I can tell, we are defining a circle of radius r and height z. It probably has to do with the fact that e_r hat is
18.

18

$$\left.\frac{d}{dt}\right|_o r_{p/o} = \cancel{e} \; v_{p/o} = \dot{r}\hat{e}_r + r\dot{\theta}\hat{e}_\theta + \dot{z}\hat{e}_z$$

$$a_{p/o} = \ddot{r}\hat{e}_r + \dot{r}\dot{\hat{e}}_r + (r\dot{\theta})'\hat{e}_\theta + r\dot{\theta}\dot{\hat{e}}_\theta + \ddot{z}\hat{e}_z + \dot{z}\dot{\hat{e}}_z$$

$$a_{p/o} = \ddot{r}\hat{e}_r + \dot{r}\dot{\hat{e}}_r + \dot{r}\dot{\theta}\hat{e}_\theta + r\ddot{\theta}\hat{e}_\theta + r\dot{\theta}\dot{\hat{e}}_\theta + \ddot{z}\hat{e}_z + \dot{z}\dot{\hat{e}}_z$$

$$\dot{\hat{e}}_r = \dot{\theta}\hat{e}_\theta$$

$$\dot{\hat{e}}_\theta = -\dot{\theta}\hat{e}_r$$

$$= \ddot{r}\hat{e}_r + \dot{r}\dot{\theta}\hat{e}_\theta + \dot{r}\dot{\theta}\hat{e}_\theta + r\ddot{\theta}\hat{e}_\theta - \dot{\theta}r\dot{\theta}\hat{e}_r + \ddot{z}\hat{e}_z + 0$$

$$= (\ddot{r} - r\dot{\theta}^2)\hat{e}_r + (2\dot{r}\dot{\theta} + r\ddot{\theta})\hat{e}_\theta + \ddot{z}\hat{e}_z$$

19.

(19)

$$\vec{A} \cdot \frac{d\vec{A}}{dt} = 0$$

$$\vec{A} \cdot \vec{A} = |\vec{A}||\vec{A}| \cos(0)$$

$$\vec{A} \cdot \vec{A} = |\vec{A}|^2$$

$$\frac{d}{dt}(\vec{A} \cdot \vec{A}) = \frac{d}{dt}|\vec{A}|^2$$

Derivative of dot product

$$\frac{d}{dt}\left(r(t) \cdot s(t)\right) = r(t)\frac{ds}{dt} + s(t)\frac{dr}{dt}$$

Same as product rule

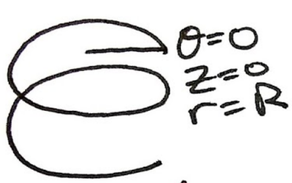
$$\frac{d\vec{A}}{dt}\vec{A} + \frac{d\vec{A}}{dt}\vec{A} = \cancel{\frac{d}{dt}}\, 0$$

$$2\vec{A}\frac{dA}{dt} = 0$$

$$\vec{A}\frac{dA}{dt} = 0$$

20. I was told to “Come up with a function in cylindrical coordinates that can be used to describe the path”. I’m not convinced that I have actually done that.

(20)



$$r(z) = R\hat{e}_r$$

$$\theta(z) = -\frac{2\pi}{P} z$$

$$\vec{a} = (\cancel{\ddot{r}} - r\dot{\theta}^2)\hat{e}_r + (\cancel{2\dot{r}}\dot{\theta} + r\ddot{\theta})\hat{e}_\theta + \ddot{z}\hat{e}_z$$

$$\vec{a} = -r\dot{\theta}^2\hat{e}_r + r\ddot{\theta}\hat{e}_\theta + \ddot{z}\hat{e}_z$$

21. These seem like reasonable parameters for a large slide and a small person.

21

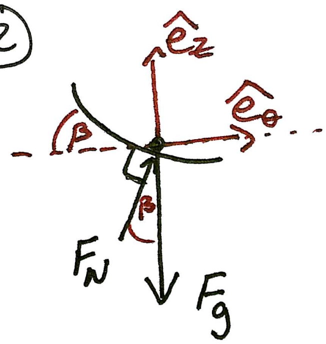
$R = 1\,m$

$M = 60\,kg$

$\beta = 30^\circ = \pi/6$

22. First model will include interactions between the person, the slide. The first model will not address air resistance, or friction.
23. The model will include gravity, and a normal force keeping the person from falling through the slide or the wall.
24. Gravity acts in the z direction. The normal force acts in the r, theta, and z direction to keep keep the radius constant, to keep moving in a circle, and to accelerate the person down the slide but not at the acceleration of gravity,
25. This free body diagram seems mostly right. I intended the normal force to include the force of the wall so the person doesn't fly off.

22



26.
27. I feel like I’m actually pretty close to simulating these problems. I just can’t seem to get it to click with solving ode’s with Mathematica.
28. .
29.