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```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%  ASEN 3128 HW 3
%
%  Author: Caleb Bristol
%  Due Date: 24 February, 2022
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

Clean Your Workstation

```
clc
clear
```

Problem 1

Constants (Vector and Individual Form)

```
% State Vector
x_ = [100;100;-1600;0.17;0.17;2.4;1;-1;0;0;0;0];
x = x_(1);
y = x_(2);
z = x_(3);
phi = x_(4);
theta = x_(5);
psi = x_(6);
u = x_(7);
v = x_(8);
w = x_(9);
p = x_(10);
q = x_(11);
r = x_(12);
```

```
% State Derivative Vector
x_dot_ = [-0.04;1.37;-0.34;0;0;0;-1.68;1.66;-0.3;-20.79;-15.37;0];

% As pulled from the lab document:
%
% For Parrot Mamba Minidrone
g = 9.81;       %[m/s^2]
m = 0.068;      %[kg]
R = 0.060;      %[m]
k_m = 0.0024;   %[Nm/N]
I_x = 6.8E-5;   %[kg*m^2]
I_y = 9.2E-5;   %[kg*m^2]
I_z = 1.35E-4;  %[kg*m^2]
nu = 1E-3;      %[N/(m/s)^2]
mu = 2E-6;      %[Nm/(rad/s)^2]
```

Determine Forces and Moments

The methodology for this section was to calculate the aerodynamic forces and moments first, based off the velocity and angular velocity of the craft, then utilize equations of motion to extract the control forces and moments second.

Aerodynamic Forces and Moments

```
% Aerodynamic Drag Force
airspeed = norm(x_(7:9));

D = nu * airspeed^2;

f_aero = -D * x_(7:9) / norm(x_(7:9));

% Aerodynamic Moments
m_aero = -mu * norm(x_(10:12)) * x_(10:12);
```

Control Forces and Moments

```
% Control Forces
f_c = m*(x_dot_(7:9)) - m*([r*v-q*w;p*w-r*u;q*u-p*v] + g*[-
sin(theta);cos(theta)*sin(phi);cos(theta)*cos(phi)]) - f_aero;

% Control Moments
I_B = [I_x 0 0;0 I_y 0;0 0 I_z];

m_c = I_B*(x_dot_(10:12) - [(I_y-I_z)*q*r/I_x;(I_z-I_x)*r*p/
I_y;(I_x-I_y)*p*q/I_z] - I_B^(-1)*m_aero);
```

Determine Motor Thrust Forces

```
% Done Utilizing Function from Lab
f_ = ComputeMotorForces(f_c(3),m_c(1),m_c(2),m_c(3),R,k_m);
```

Display Results

```
fprintf('PROBLEM 1: \n \n')
fprintf('The aerodynamic forces acting on the craft [N] were: \n')
disp(f_aero)
fprintf('The aerodynamic moments acting on the craft [Nm] were:
 \n')
disp(m_aero)
fprintf('The control forces acting on the craft [N] were: \n')
disp(f_c)
fprintf('The control moments acting on the craft [Nm] were: \n')
disp(m_c)
fprintf('The force exerted by motors 1 through 4 [N] were: \n')
disp(f_)
```

```
PROBLEM 1:

The aerodynamic forces acting on the craft [N] were:
   -0.0014
    0.0014
         0

The aerodynamic moments acting on the craft [Nm] were:
     0
     0
     0

The control forces acting on the craft [N] were:
    0.0000
    0.0002
   -0.6684

The control moments acting on the craft [Nm] were:
   -0.0014
   -0.0014
         0

The force exerted by motors 1 through 4 [N] were:
    0.1671
    0.1838
    0.1671
    0.1504
```

Problem 2

TRUE

Explanation

Considering that the quadrotor was in steady hover, the control forces applied should be just enough that the aircraft experiences thrust equal to its weight in the z-direction, exactly enough to counteract the force of gravity. Now consider the addition of some delta theta, or instantaneous pitch. The force of gravity will still act in the downwards direction with equal magnitude, but if the forces applied by the motors don't change, then the force applied by the motors will no longer be opposing the force of gravity, because the aircraft will be pitched. It will begin to translate in the x direction but more importantly will begin to descend. Because the force applied by the motors opposing the direction of gravity will no longer be equal to gravity g, but g times the cosine of delta theta, it will not be enough to counteract gravity unless theta is zero, which according to our instantaneous pitch added, it is not. Therefore, the force applied by the motors will be slightly less than that of gravity and the aircraft will slowly begin to descend in the downwards direction, and descend.

Therefore, the statement is TRUE.

Display Results?

```
fprintf('PROBLEM 2: \n \n')
fprintf('TRUE: see commented code for detailed explanation. \n')
```

```
PROBLEM 2:

TRUE: see commented code for detailed explanation.
```

Functions

This function was pulled from Lab 3

```
function motor_forces = ComputeMotorForces(Zc, Lc, Mc, Nc, R, km)
```

ComputeMotorForces

Compute the individual motor forces given the required control forces

```
M = [-1 -1 -1 -1;-R/sqrt(2) -R/sqrt(2) R/sqrt(2) R/sqrt(2); ...
    R/sqrt(2) -R/sqrt(2) -R/sqrt(2) R/sqrt(2); km -km km -km];

F_c = [Zc;Lc;Mc;Nc];

motor_forces = M^(-1) * F_c;

end
```

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