AAE 42100 **Exam 1** (Open-Book Open-Notes) **Name**______________________
Due 12pm Oct 3rd, 2020 (Print Your Name)

I certify that I have neither given help to, nor received help from, any individual in matters relating to this examination.

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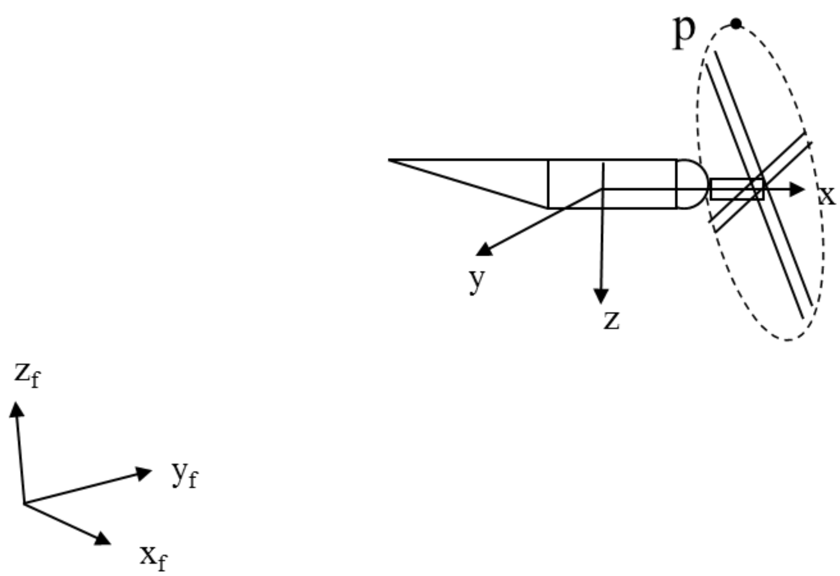
Signature

Problem 1. (20 pts)
The rotorcraft shown below is flying in an inertial reference frame O (xf,yf,zf). The center of the rotor blade system is located at 10 i ft and the blades rotate (non-deformed) in a plane perpendicular to the rotor axis with a rotational rate of 300 rpm, counter clockwise looking from left to right. The rotor blades have a radius of 20 feet. At a given instant in time the rotorcraft has the following motion state:

$U = 80$ fps $V = 20$ fps $W = 30$ fps

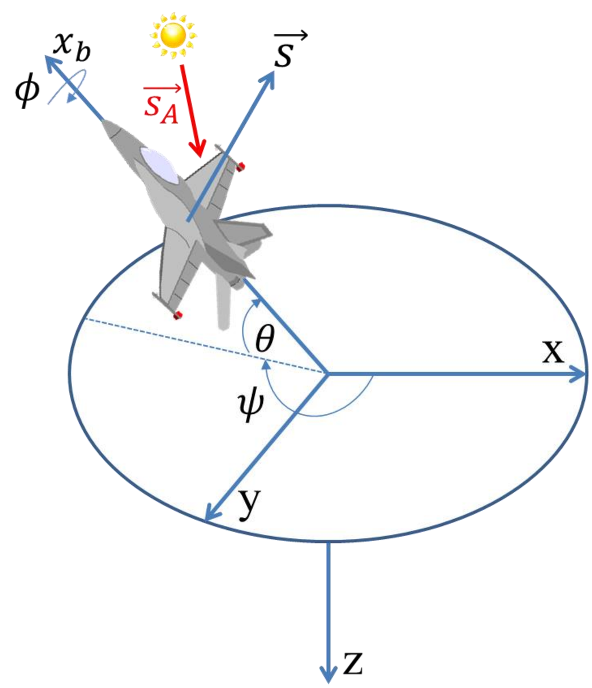
$P = 0.1 \text{ rad/sec}$ $Q = 0.15 \text{ rad/sec}$ $R = 0.05 \text{ rad/sec}$



(a) Sketch the traditional vectors $\boldsymbol{R_0}$, $\boldsymbol{r}$, and $\boldsymbol{R}$ used to define the location of the point.

(b) Determine the inertial velocity of point P at the instant in time where the point moves through its **most top** position with respect to the moving frame.

Problem 2. (20 pts)
An aircraft made a sequence of 3-2-1 rotations with Euler angles $\Psi = 120^o$, $\Theta = 30^o$ and $\Phi = 10^o$. The vector $\vec{S}$ is along the z body axis of the aircraft. Vector $\overrightarrow{S_A}$ represents the sun light direction. Find the relative angle between $\vec{S}$ and $\overrightarrow{S_A}$ when the Sun has azimuth angle $\mathrm{a} = 30^o$ and elevation angle $\mathrm{e} = 45^o$.



Problem 3. (20 pts)
Suppose that for an airplane the slope of the C_m versus C_L curve is -0.15 and C_m=0.08 at C_L=0.

(a) (10pts) Determine the trim lift coefficient

(b) (10pts) If x_{cg}= $0.3\bar{c}$, determine the neutral point location h_n

Problem 4. (20 pts)

(a) List all of the equations for a reference condition under level, steady, symmetric, no rotational velocities flight.

(b) Based on the above reference condition, derived the linear perturbation flight dynamics equations for Y force, $m(\dot{v} + u_0 r) = \Delta Y + mg\cos(\theta_0)\phi$. (Show all steps!)

Problem 5. (20 pts)
An airplane is in a constant-speed, constant-altitude (u_0=constant, h_0=constant, $w_0=v_0=\theta_0=0$) steady turn with a constant roll angle ϕ_0<90° and constant turning rate Ω. The figure above shows the front view of the trim flight. Ignore any effects of rotors internal to the airplane.

(a) Show that the trim values of the angular rates are

$$q_0 = \Omega \sin \phi_0$$
$$r_0 = \Omega \cos \phi_0$$
$$p_0 = 0$$

Show all of your steps!

(b) Determine the expressions for the trim values of Y_0, L_0, M_0, and N_0.

Bonus (5 pts)
For problem 5, obtain the linearized y-force equation using the above trim condition. Show your work and clearly write down the result. Are the longitudinal and lateral linearized dynamics of the airplane in this case decoupled?