AEM 338 Project #1

Due: 21st April 2017 by 5:00pm

Groups of 3 or 4 or 5 or 6.

Prepare a short memo describing the flight performance of a Cessna 172 (CDo = 0.034) at a gross weight of 2500 lbs with the following powerplants:

In Class and on website

A. Continental O-300: 145 hp at 2700 rpm with a fixed pitch 76 inch cruise prop (standard early 172).

~~B. Continental IO-360: 210 hp at 2700 rpm with a fixed pitch 78 inch climb prop (USAF T-41C @ USAFA)~~

C. Continental IO-360: 210 hp at 2700 rpm with a fixed pitch 78 inch cruise prop (USAF T-41C non-standard)

~~B. Continental IO-360: 210 hp at 2700 rpm with a variable pitch 78 inch prop (USAF T-41D @ USAFA)~~

Evaluate and compare the following performance metrics:

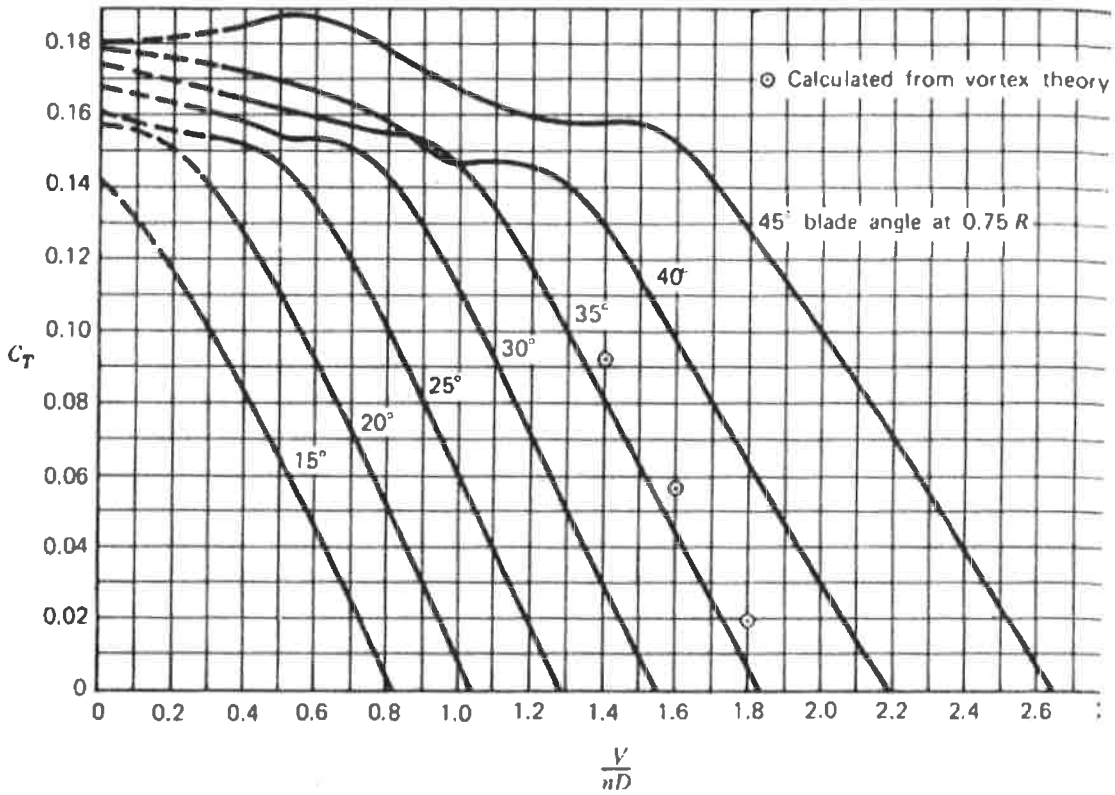
- ~~50 foot obstacle~~ takeoff distance at SSL and 10000 feet (standard day) on concrete.
- ~~Rate of climb versus altitude~~
- Max cruise speed at SSL

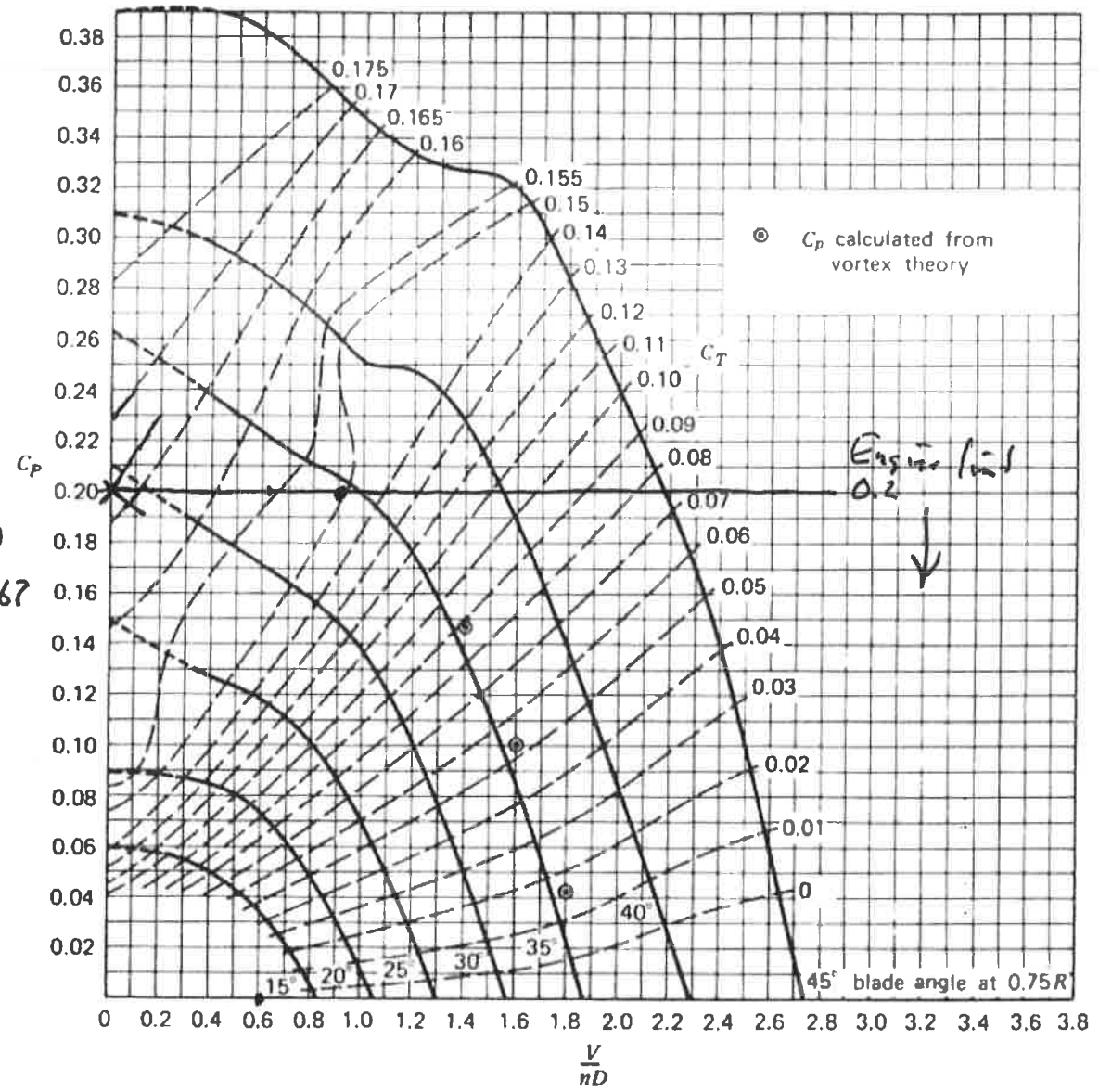
aircraft C takeoff cruise

For aircraft C, estimate the takeoff distance and max cruise velocity for a cruise prop.

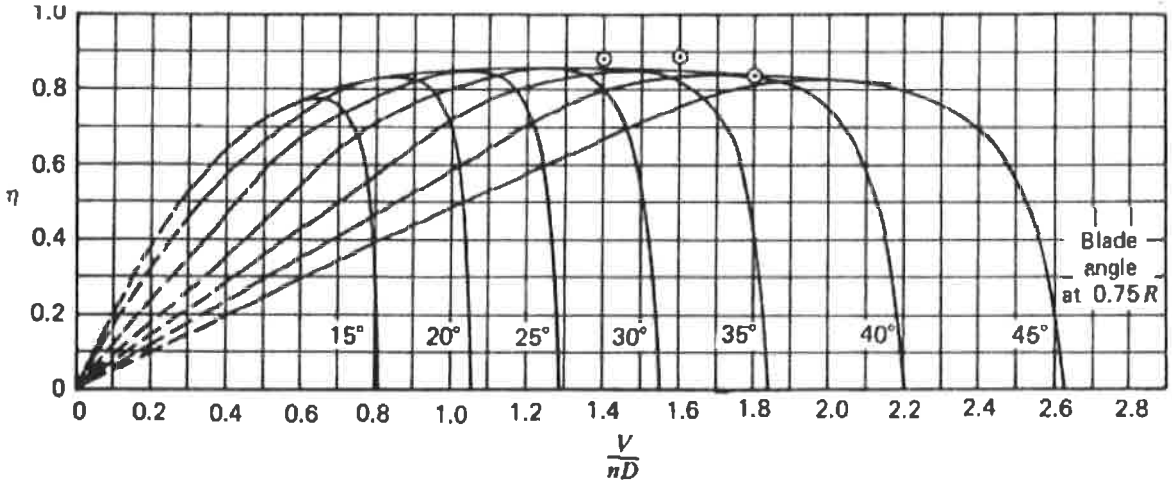
Notes:

- A climb prop is a propeller with the pitch necessary to maximize the rate of climb performance
- A cruise prop is a propeller that maximizes the cruise velocity.
- Use the propeller curves attached below. Blade angles are between 15 and 45 degrees.
- Include the trim drag resulting from operating at a particular CL. (e.g. takeoff rotation)
- Do not exceed 2700 rpm **or** 210 hp at any point in the flight
- ~~You may wish to add 10° flaps during the takeoff roll to reduce the ground roll~~
- The memo should contain two sections: 1) a one-page summary and 2) a detailed explanation and discussion of your analysis including an appendix of computer codes.




C_P
C_T
C_p calculated from vortex theory
0.175
0.17
0.165
0.16
0.155
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
15°
20°
25°
30°
35°
40°
45° blade angle at 0.75R
$\frac{V}{nD}$

29° BA
C_T : 0.167


η
Blade angle at 0.75R
15°
20°
25°
30°
35°
40°
45°
$\frac{V}{nD}$

$$C_p = \frac{P}{\rho n^3 D^5}$$

hp	550 ft·lbf/s	ft⁵	s²		slug ft
	× hp	slug	rev³	ft⁵	lbf s²

$$J = \frac{V}{nD} \qquad C_T = \frac{T}{\rho n^2 D^4}$$

$$P_{req} = \sqrt{\frac{2W^3}{\rho S}} \left(\frac{C_D}{C_L^{3/2}} \right)$$

$$= \frac{C_D}{C_L} W V_\infty$$

$$C_L = \frac{W}{\frac{1}{2}\rho V^2 S}$$

$$P_{avail} = \eta P_{engine}$$

$$\eta C_p \rho n^3 D^5 = \frac{C_D}{C_L} W V_\infty = \left(C_{D_0} + k C_L^2 \right) \frac{\rho V^2 S}{2W} W V_\infty$$

$$= \left[C_{D_0} + k \left(\frac{4W^2}{\rho^2 V^4 S^2} \right) \right] \frac{\rho V^2 S}{2} V$$

$$P_{engine} \approx P_{2700\,rpm} \frac{RPM}{RPM_{2700}} \frac{n}{n_{max}} = C_p \rho n^3 D^5 \Rightarrow \frac{P_{max}}{n_{max}} = C_p \rho n^2 D^5$$

$$n^2 = \sqrt{\frac{P_{max}}{n_{max}} \frac{1}{C_p \rho D^5}}$$

$$\frac{dV}{dt} = g\left(\frac{T}{W} - \frac{D}{W} - \mu_r \left(1 - \frac{L}{W} \right) \right)$$

$$= g\frac{T}{W} - g\frac{D}{W} - g\mu_r + g\frac{L}{W}$$

$$q = \frac{1}{2}\rho V^2$$

$$= \frac{slug}{ft^3}\ \frac{ft^2}{s^2}\ \frac{lbf\ s^2}{slug\ ft}\ ft^2$$

$$V^2 = \frac{W}{\frac{1}{2}\rho C_L S}$$

$$s = \frac{1}{2} a t^2$$

$$V = at \qquad t = \frac{V}{a}$$

$$s = \frac{1}{2} a \frac{V^2}{a^2} = \frac{1}{2}\frac{V^2}{a}$$

$$a = \frac{1}{2}\frac{V^2}{s}$$

$$= \frac{1}{2}\frac{88^2\ ft^2/s^2}{700\ ft} = 5.5\ ft/s^2$$

$$t = 16^s$$