MAE 158 Recommended Homework 10
Winter 2022

From Shevell, *Fundamentals of Flight* Problems 16.1, 16.4, 17.1, 17.3

16.1. A large turboprop transport has the following characteristics:

$$\text{wing area, } S_W = 3520 \text{ ft}^2$$
$$\text{wing span, } b_W = 155 \text{ ft}$$
$$\text{mean aerodynamic chord, } \bar{c} = 25.0 \text{ ft}$$
$$\text{horizontal tail aspect ratio} = 4.2$$
$$\text{tail length, } l'_H = 83.0 \text{ ft.}$$

The airplane has a T-tail, the horizontal being mounted on top of the vertical tail. The wing is unswept. The fuselage and nacelle contribution to stability about the quarter-chord is unstable; that is,

$$\left(\frac{dC_M}{dC_L}\right)_{\substack{\text{fuselage}\\+\text{nacelle}}} = 0.06; \quad \text{also} \quad \frac{d\epsilon_H}{d\alpha}\text{(at the tail)} = 0.50$$

Assume that the wing and tail have elliptical lift distributions so that $dC_L/d\alpha = a_0/(1 + 57.3\, a_0/(\pi AR))$ (per degree). The most aft allowable center of gravity position, at which stability, dC_M/dC_L, is at least -0.10, is 35% of the m.a.c. (Note that $dC_M/dC_L = -0.10$ corresponds to the c.g. being 10% of the mean aerodynamic chord ahead of the 'neutral' point.) Determine the horizontal tail area.

16.4. A DC-8-50, the original turbofan-powered version of the DC-8, has the following characteristics:

$$\text{wing area, } S_W = 2883 \text{ ft}^2$$
$$\text{wing span, } b_W = 148.4 \text{ ft}$$
$$\text{mean aerodynamic chord, } \bar{c} = 22.98 \text{ ft}$$
$$\text{horizontal tail area, } S_H = 559.1 \text{ ft}^2$$
$$\text{horizontal tail span, } b_H = 47.5 \text{ ft}$$
$$\text{tail length, } l'_H = 68.4 \text{ ft.}$$

The total of the wing, fuselage, and nacelle contributions to stability is slightly stable about the $\bar{c}/4$ point; that is,

$$\left(\frac{dC_M}{dC_L}\right)_{\substack{\text{wing+}\\\text{fuselage}\\+\text{nacelle}}} = -0.04$$

At the tail,

$$\frac{d\epsilon_H}{d\alpha} = 0.45$$

Assuming that the wing and tail have elliptical lift distributions so that $dC_L/d\alpha = a_0/(1 + 57.3\, a_0/(\pi \text{AR}))$ (per degree), what is the most aft allowable center of gravity position at which stability, dC_M/dC_L, is at least -0.10?

17.1. A proposed twin-engine turboprop transport airplane will cruise at 28,000 ft at a true speed of 400 mph. Air temperature is 430°R. The airplane will be powered by engines with a takeoff rating of 1,500 shp and a maximum cruise rating at 28,000 ft of 800 shp. At cruise, propeller speed is 1200 revolutions per minute.

(a) Assuming four-bladed propellers, with a blade activity factor of 135, so that the propeller chart in Figure 17.20 is directly applicable, find the variation of propulsive efficiency with propeller diameter. What propeller diameter would you choose to obtain the highest cruise efficiency at maximum cruise power? (Assume several propeller diameters and determine their efficiencies. Plot η versus diameter. Check additional values of diameter as necessary to locate the optimum.)

(b) What is the ideal efficiency of the propeller you selected?

17.3. A turboprop-powered Navy P3V is flying at 350 mph at 20,000 ft on a standard day. Each of the four 14-ft-diameter propellers is delivering 1750 lb of thrust. What is the *ideal* efficiency of this propeller?

For problem 17.1

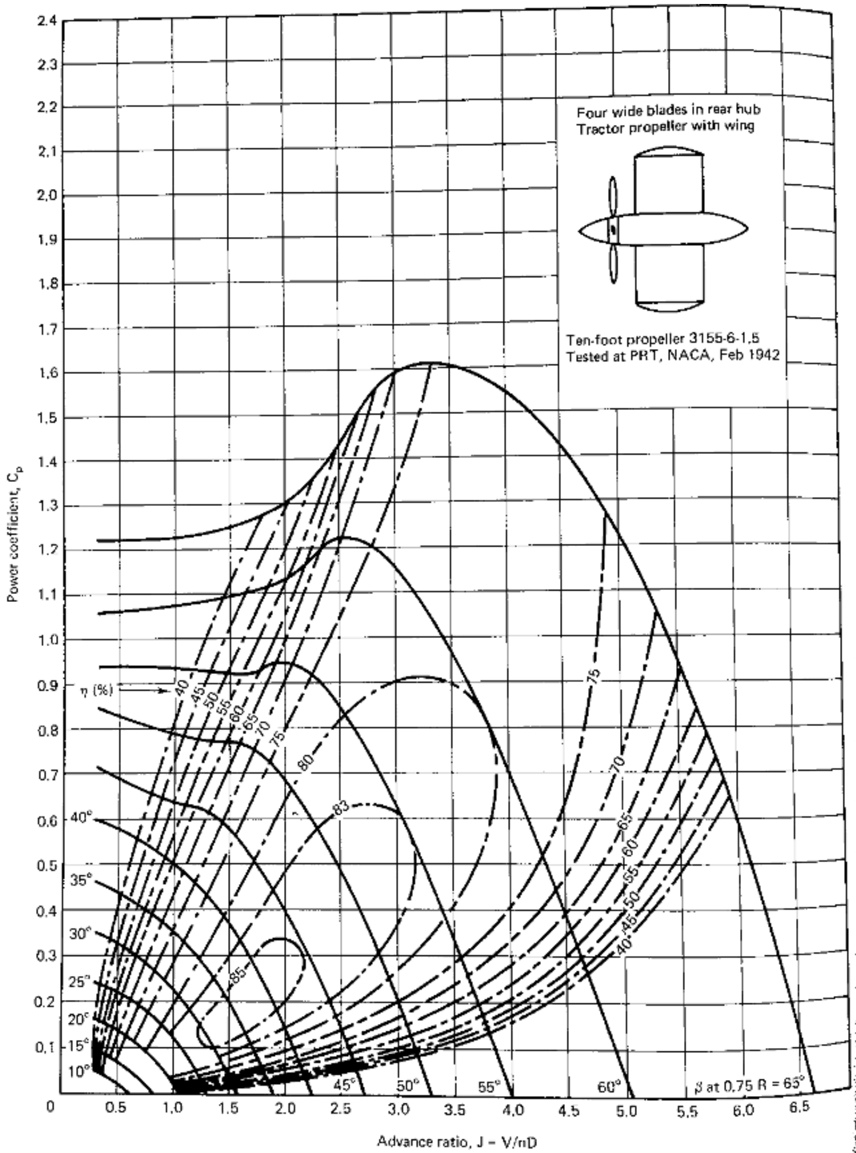

Figure 17.20 Propeller chart for a four-bladed tractor propeller with a blade activity factor of 135. Reprinted with permission from Bierman, Gray, and Maynard, "Wind-Tunnel Tests of Single and Dual-Rotating Tractor Propellers of Large Blade Width," NACA Wartime Rep. L-286, Sept. 1942.