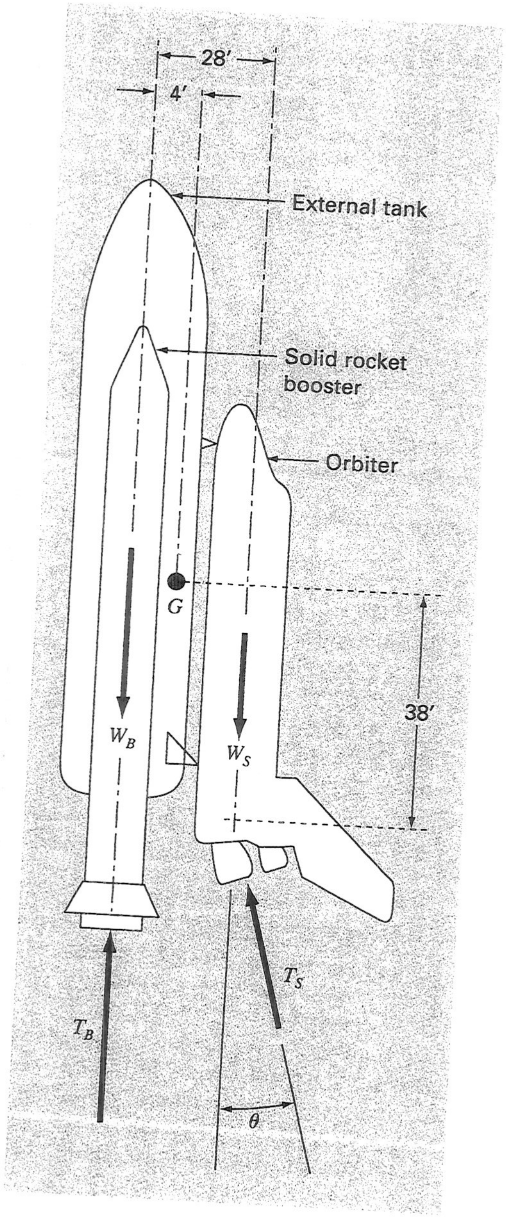
DR BAUER
SUM '11

HWK #3
due JUNE 24

EGN 3420

PROB FROM CHAPRA & CANALE, NUMERICAL METHODS FOR ENGINEERS, McGRAW-HILL, 6th EDITION, 2010, PP 221-222




**8.46** The space shuttle, at lift-off from the launch pad, has four forces acting on it, which are shown on the free-body diagram (Fig. P8.46). The combined weight of the two solid rocket boosters and external fuel tank is $W_B = 1.663 \times 10^6$ lb. The weight of the orbiter with a full payload is $W_S = 0.23 \times 10^6$ lb. The combined thrust of the two solid rocket boosters is $T_B = 5.30 \times 10^6$ lb. The combined thrust of the three liquid fuel orbiter engines is $T_S = 1.125 \times 10^6$ lb.

At liftoff, the orbiter engine thrust is directed at angle $\theta$ to make the resultant moment acting on the entire craft assembly (external tank, solid rocket boosters, and orbiter) equal to zero. With the resultant moment equal to zero, the craft will not rotate about its mass center $G$ at liftoff. With these forces, the craft will have a resultant force with components in both the vertical and horizontal direction. The vertical resultant force component is what allows the craft to lift off from the launch pad and fly vertically.

The horizontal resultant force component causes the craft to fly horizontally. The resultant moment acting on the craft will be zero when $\theta$ is adjusted to the proper value. If this angle is not adjusted properly, and there is some resultant moment acting on the craft, the craft will tend to rotate about it mass center.

**(a)** Resolve the orbiter thrust $T_S$ into horizontal and vertical components, and then sum moments about point $G$, the craft mass center. Set the resulting moment equation equal to zero. This equation can now be solved for the value of $\theta$ required for liftoff.

**(b)** Derive an equation for the resultant moment acting on the craft in terms of the angle $\theta$. Plot the resultant moment as a function of the angle $\theta$ over a range of $-5$ radians to $+5$ radians.

**(c)** Write a computer program to solve for the angle $\theta$ using Newton's method to find the root of the resultant moment equation. Make an initial first guess at the root of interest using the plot. Terminate your iterations when the value of $\theta$ has better than five significant figures.

**(d)** Repeat the program for the minimum payload weight of the orbiter of $W_S = 195{,}000$ lb.

WRITE A MATLAB™ PGM USING THE NEWTON RAPHSON METHOD TO FIND THE ROOT OF THE MOMENT EQUATION.
SEE NEXT PAGE FOR HELP. (GRAPHS IN f(x) VS RADIANS)
REPORT ANSWERS IN DEGREES.

# for Homework 3

$X = \Theta$

$$f(x) = LGB * WB - LGB * TB - LGS * WS + LGS * TS * \cos(x) - LTS * TS * \sin(x)$$

$$\frac{d f(x)}{dx} = f'(x) = -LGS * TS * \sin(x) - LTS * TS * \cos(x)$$

N/R Method

$$X_{next} = X_{old} - \frac{f(X_{old})}{f'(X_{old})}$$

DEG = RADIANS (180/π)

TURNIN :

a) PROGRAM CODE

b) 2 graphs @ different weights

c) zeros finds at different w...