1.1)

Given:

T-38A weighing 10,000 *lbf* and flying at 20,000 *ft*

From Fig. P1.1, the maximum Mach number with afterburner ("Max" thrust curve) is $M \approx 1.075$. From Table 1.2b, the standard day speed of sound at 20,000 *ft* is 1036.94 *ft/s*. Using the definition of the Mach number as $M \equiv V/a$ (the instructor may have to give this definition to the students since it is not found in Chapter 1), the velocity is:

$$V = Ma = (1.075)(1036.94\,ft/s) = 1114.7\ ft/s$$

The maximum lift-to-drag ratio, $(L/D)_{max}$, occurs at the point of minimum drag, $D_{min} = 850\ lbf$. Assuming that the airplane is in steady, level, unaccelerated flight, $L = W = 10{,}000\ lbf$, and:

$$(L/D)_{max} = 10{,}000 lbf / 850 lbf = 11.76$$

The Mach number where this occurs is $M \approx 0.53$. The minimum velocity of the aircraft under the given conditions is $M \approx 0.34$ and is due to the buffet (or stall) limit.

1.2)

Given:

T-38A weighing 10,000 *lbf* and flying at 20,000 *ft* with "Mil" thrust at $M = 0.65$

From Eqn. 1.1, the total energy of the aircraft is:

$$E = 0.5mV^2 + mgh$$

The mass of the airplane is given by Eqn. 1.2:

$$m = W/g = 10{,}000 lbf / 32.174 ft/s^2 = 310.81\ slugs$$

As in Problem 1.1, the velocity of the airplane can be found as:

$$V = Ma = (0.65)(1036.94\,ft/s) = 674.01\ ft/s$$

which yields a total energy of:

$$\begin{aligned} E &= 0.5mV^2 + mgh \\ &= 0.5(310.81 slugs)(674.01 ft/s)^2 + (310.81 slugs)(32.174 ft/s)(20{,}000 ft) \\ &= 270.60 \times 10^6\ ft\text{-}lbf \end{aligned}$$

1.2) contd.

The energy height is given by Eqn. 1.3:

$$H_e = E/W = 270.60 \times 10^6 \; ft - lbf \,/ 10{,}000 lbf = 27{,}060 \; ft$$

The specific excess power is given by Eqn. 1.7:

$$P_s = \frac{(T-D)V}{W}$$

At the given conditions, $T = 2{,}500 \; lbf$ and $D = 1{,}000 \; lbf$ from Fig. P1.1, and the specific excess power is:

$$P_s = \frac{(T-D)V}{W} = \frac{(2{,}500 lbf - 1{,}000 lbf)(674.01 ft/s)}{10{,}000 lbf} = 101.1 \; ft/s$$

1.3)

Given:

T-38A weighing 10,000 *lbf* and flying at 20,000 *ft* with "Mil" thrust at $M = 0.65$

The acceleration possible is given by Eqn. 1.5 as:

$$\frac{(T-D)V}{W} = \frac{V}{g}\frac{dV}{dt}$$

For the conditions of Problem 1.2, the acceleration would be:

$$\frac{dV}{dt} = \frac{(T-D)V}{W}\frac{g}{V} = P_s \frac{g}{V} = (101.1 ft/s)\frac{32.174 ft/s^2}{674.01 ft/s} = 4.826 ft/s^2$$

The rate of climb is given by Eqn. 1.7 as:

$$\frac{dh}{dt} = P_s = 101.1 ft/s = 6{,}066 ft/m$$

1.4)

Given:

T-38A flying at 20,000 *ft* with weight of 8,000, 10,000, and 12,000 *lbf*

As in Problem 1.1, the maximum lift-to-drag ratio, $(L/D)_{max}$, occurs at the minimum drag, D_{min}. Also, assuming that the airplane is in steady, level, unaccelerated flight, $L = W$. For the three weights you can generate a table for finding $(L/D)_{max}$ using values from Fig. P1.1 and Tab. 1.2b:

$W = L$ (*lbf*)	D_{min} (*lbf*)	$(L/D)_{max}$	$M_{(L/D)_{max}}$	$V_{(L/D)_{max}}$ (*ft/s*)
8,000	650	12.31	0.47	487.3
10,000	850	11.76	0.53	549.6
12,000	1050	11.43	0.60	622.2

As can be seen, higher weight requires higher velocities to maintain aerodynamic efficiency, but also results in a reduction of that efficiency.

1.5)

Given:

10,000 *lbf* T-38A flying at 20,000 *ft* at $M = 0.35$, $M_{(L/D)_{max}}$, and 0.70

As in Problem 1.2, the specific excess power is given by Eqn. 1.7:

$$P_s = \frac{(T - D)V}{W}$$

For the three velocities you can generate a table for specific excess power using values from Fig. P1.1:

M	T (*lbf*)	D (*lbf*)	V (*ft/s*)	P_s (*ft/s*)
0.35	2250	1600	362.93	23.6
0.53	2400	850	549.58	85.2
0.70	2600	1100	725.86	108.9

Notice the large increase in specific excess power from $M = 0.35$ to 0.53 as the airplane becomes more aerodynamically efficient. While the specific excess power continues to increase as the speed increases to $M = 0.70$, the increase in P_s is not as dramatic due to the increase in drag.