1e.)

a) units of eigenvalues: speed, m/s

b) units of f_1, f_2: $f_1 = \frac{kg}{m^2 \cdot s}$, $f_2 = \frac{kg}{m \cdot s^2}$

c) units of u: $u_1 = \frac{kg}{m^3}$, $u_2 = \frac{kg}{m^2 \cdot s}$

d) Yes, the eigenvalues depend on the state vector because they include u, which is u_2/u_1.

e) λ_2 will always be positive as long as u is positive.

$\lambda_1 = u - a = Ma - a = a(M-1)$.

$\lambda_1 = a(M-1)$. We see that λ_1 is positive when $M > 1$, and negative when $M < 1$. (Assuming positive velocity).