Problem 222C

A turbojet engine ingests air at a velocity of 100 m/s and a density of 1 kg/m^3. The velocity is uniform and the cross-sectional area of the approaching stream which enters the engine is 0.1 m^2. The velocity of the exhaust jet from the engine, however, is not uniform but has a velocity which varies over the cross-section according to

$$u(r) = 2U^* \left(1 - \frac{r^2}{r_0^2}\right)$$

where the constant $U^* = 600$ m/s and r_0 is the radius of the jet cross-section. The radial position within the axisymmetric jet is denoted by r and the density of the exhaust jet is assumed to be uniform. It is readily shown that the above formula implies that U^* is the average velocity of the exhaust jet (the volume flow divided by the cross-sectional area of the jet).

(a) Find the thrust of the turbojet engine.

(b) Find what the thrust would be if the exhaust jet had a uniform velocity, U.

Assume the pressures in both the inlet and exhaust jets are the same as the surrounding air and that mass is conserved in the flow through the engine (roughly true in practice).