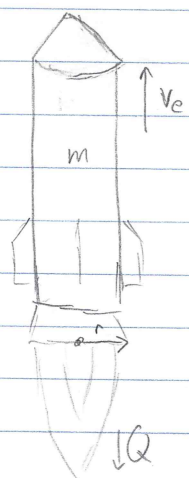
20-P-MOM-DY-35

space A rocket ship has the mass $m = 10000$ kg, 5000 kg of which is fuel with the density $\rho = 1004$ kg/m³. The exit nozzle of the rocket is a circle with a radius X $r = 5$m and fuel exits the nozzle at a volumetric rate $Q = 50$ m³/s. If the escape velocity of Earth is 11.19km/s, what velocity relative to the rocket ship does the fuel need to be ejected to reach the escape velocity by the time the fuel runs out. [no need for radius]



Solution: $v_{max} = v_{f/r} \ln\left(\frac{m}{m-m_f}\right) - \frac{g m_f}{c}$ $\quad c = \frac{dm}{dt}$

$c = \rho Q = 50\,200$ kg/s

$$11190 = v_{f/r} \ln\left(\frac{10000}{5000}\right) - \frac{(9.81)(5000)}{50\,200}$$

$v_{f/r} = 16.145$ km/s