AAE 334 Fall 2015
Extra Credit Project

Due at the beginning of class
Friday, November 20, 2015
(Hardcopy or emailed pdf file)

In the novel The Martian by Andy Weir (Crown Publishing, New York, 2014), and in the recent movie (20th Century Fox, 2015), the crew of a Mars-bound spacecraft need to decelerate their ship to rescue their lost crewmate. As a desperate measure to do this, they use a bomb to blow a hole in an airlock, and that produces thrust via a jet of air into space. According to the book, and some statements by the author online, the jet would generate a net change in velocity of 30 m/s and the spacecraft had a mass of 110 Mg (megagrams or metric tons). From stills from the movie, the spacecraft looked like a cylinder about 100 m long and 2-3 m in diameter. The airlock looked to be about 2 m in diameter, and the hole would be smaller than that.

For this project, you will analyze the problem using what we've learned in class about gasdynamics. Make whatever reasonable assumptions you need. Here is a start: Since the flow discharges to vacuum, you can assume quasi-steady choked (sonic) flow at the hole in the airlock. Assume uniform conditions inside the spacecraft, which is initially at 1 atm pressure and 300 K. Assume that the process of emptying the ship is a constant volume, isentropic process, and determine the drop in density with time from the continuity equation. (Pressure and temperature should also drop; this is what happens in the storage tanks of a blow-down wind tunnel.) There are analytical solutions to this problem of discharge of gas from a pressurized vessel (see Dutton and Coverdill, 1997), but it may be easier for you to write a simple computer program to integrate in time.

Determine the thrust, and assuming the ship is a rigid body, find the acceleration and change in velocity. Make plots of mass flow rate, thrust, and change in ship's velocity as function of time. Try to figure out how big the hole in the airlock would have to be. How much total air would have to be discharged? Would that fit into the ship? Would it probably work or not?

Write a short report on your project, typed and 2-5 pages double spaced, including figures and equations. Explain your assumptions. Use whatever resources you can find, but include references to all of them in your report. Use one of these styles for references: https://owl.english.purdue.edu/owl/section/2/ You are free to work together, but each student must write and hand in an individual report. List all your collaborators at the end of your report. This optional extra credit project will be worth up to the equivalent of 15 points on the midterm. Credit will depend on innovation, level of effort, and quality of the report.

References

J. C. Dutton and R. E. Coverdill, "Experiments to Study the Gaseous Discharge and Filling of Vessels," International Journal of Engineering Education, Vol. 13, No. 2, pp. 123-134, 1997. [Available in electronic form from the Purdue Library.]