Massachusetts Institute of Technology

16.07 Dynamics

Problem Set 1

Out date: Sept 5, 2007

Due date: Sept 10, 2007

	Time Spent [minutes]
Problem 1	
Problem 2	
Study Time	

Turn in **each problem** *on* **separate sheets** *so that grading can be done in parallel*

Problem 1 (20 points)

Foam can't hurt the Shuttle?

WING SPAN 78ft FT

FOAM PATH 56 ft FT

TIME 16.15.40.21.708

TIME 16.15.40.21.858
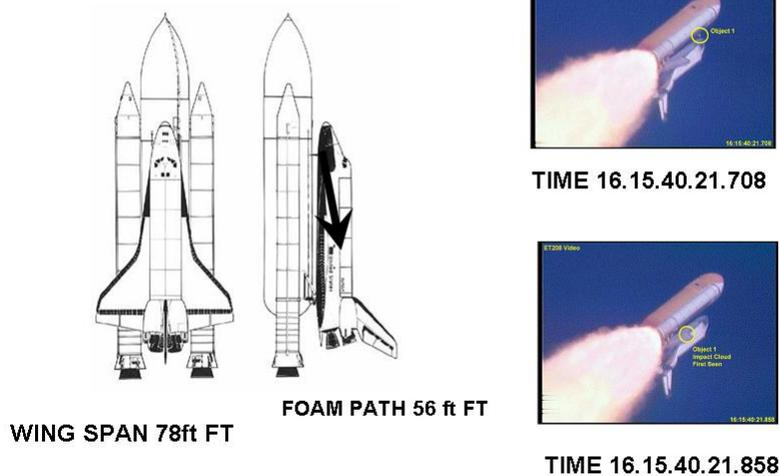
The space shuttle Columbia was damaged on liftoff when a piece of insulating foam from the bipod ramp that holds the shuttle to the external tank came loose, accelerated in the air flow and hit the leading edge of the wing. The wing span of the shuttle is 78 ft. Use 56 ft. as your estimate of the flight path length of the foam in the air stream (see figure).

V=2500 ft/sec

FOAM TRAJECTORY AND IMPACT
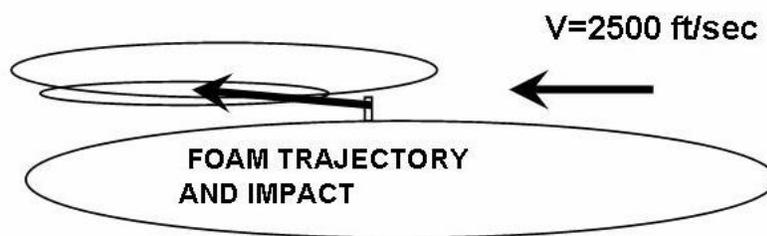
The incident occurred at an altitude of 65600 ft where the atmospheric density is .000171 slugs/cu ft. The velocity of the shuttle was 2500 fps. The foam block had a cross sectional area of 1 sq ft and a weight of 2 lbs. Assume a drag coefficient CD=1.25.

1.- Derive the equation to predict the velocity of the foam as a function of time, as well as the distance traveled as a function of time. Solve this equation using the technique shown in "Rectilinear Motion" from the Lecture 2 notes.

2.- Show that the velocity of the foam will be about 840 fps when it strikes the wing at a path length of 56. feet. At what time will this occur? Compare this flight time to the recorded flight time from video records (shown): time in hrs.min.sec. Neglect gravity.

3.- How long does it take a fluid particle to travel this distance?

4.- Estimate the error from neglecting gravity in part 1.

5.- What impulse is imparted when the foam strikes the leading edge of the wing?

6.- Compare this to the impulse M V imparted by a 17 lb wrench dropped on the shuttle from a height of 150 ft.

7.- I have often wondered whether it would have been better if the foam were lighter or heavier. A lighter form would reach a high velocity but perhaps deliver less impulse. A heavier foam would reach a lower velocity and perhaps deliver a lower impulse. Repeat your calculations fixing all initial conditions except the mass M. Take M=2M and then repeat with M=M/2. What is your conclusion? (It is easiest to do this numerically, plugging in various final velocities into your formulas for x=56.) (You might have read that ice hit the current shuttle on launch.)

Problem 2 (20 points)

The technique used to obtain an analytic solution to the governing equation of Problem 1 is not always possible. In this problem, determine the solution by a numerical approach to the solution of the ordinary differential equation using MATLAB. This will prepare you for our later uses of MATLAB both in the homework and in the extended labs.

Use the parameters given in problem 1. run your numerical method and answer the questions posed in problem 1, parts 1.1, 1.2, and 1.7.

Become familiar with the numerical approach, explore graphical presentations, have fun. Plot x(t) and v(t) vs. t for parts 1.2 and 1.7.

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