

Momentum

1. A barge with a mass of 1.5×10^5 kg is travelling at 10° north of east at 6.2 m/s. In the fog it collides with a second barge that is travelling due north. The second barge has a mass of 2.8×10^5 kg and is travelling 4.3 m/s. The barges do not stick together and immediately after the collision the second barge finds that it has been deflected by 18° east and its speed increased to 5.1 m/s.

- a) Sketch the physical situation before and after the collision.
- b) Sketch a vector representation of the momentum before and after the collision, label them 1 and 2 for the incident and 2nd barge.
- c) What are the speed and direction of the incident barge immediately after the collision?
- d) If the duration of the interaction is 1.5 minutes, determine the average Force (magnitude and direction) acting causing the impulse on the second barge.
- e) State the assumptions you made in order to solve this problem.

2. Earth orbits Sun in a nearly circular orbit with a speed 3.0×10^4 m/s. Suppose that at a certain instant, Earth's velocity is in the $-x$ direction. At this instant, the force by Sun on Earth is $\langle F_x, F_y, F_z \rangle = \langle 0, -3.6 \times 10^{22}, 0 \rangle$ Newtons. What will be Earth's momentum 1 day later? What is the Earth's change in direction in 1 day? During this time interval, the only significant force acting on Earth is the gravitational force by Sun on Earth.

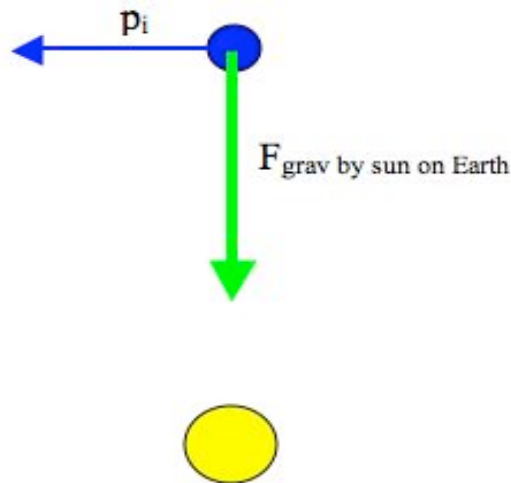


Figure: The gravitational force by Sun on Earth.

3. The thrust of a certain model rocket engine as a function of time is shown below. Here, the word "thrust" refers to the force by the expelled exhaust gas on the 31 gram rocket as the engine is firing.

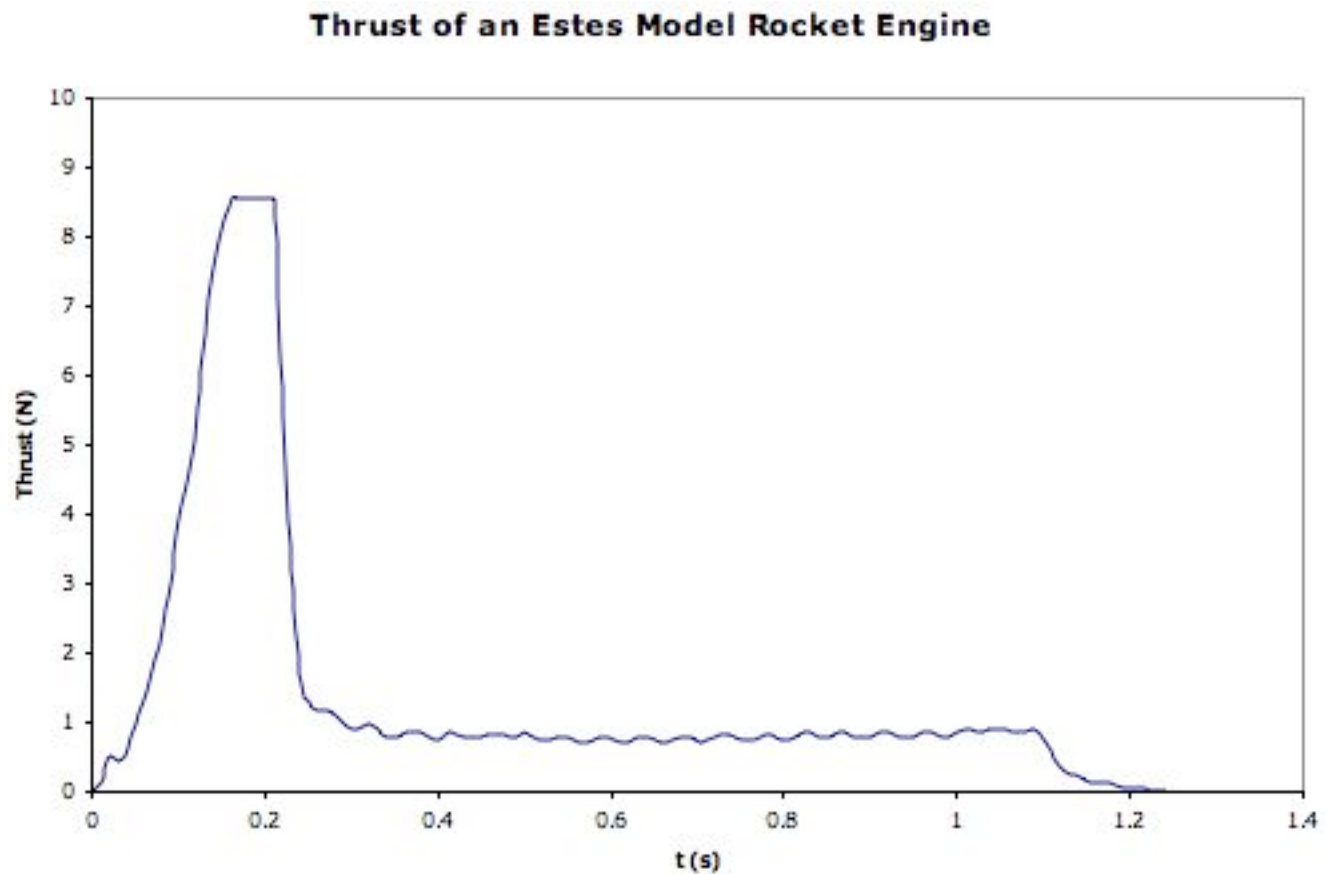


Figure: The thrust curve of a certain model rocket engine.

The total area under the curve is 1.84 N s. The total burn time of the rocket engine is 1.24 s. The peak thrust has a magnitude 8.60 N. Since force is a vector, assume that the thrust is in the +y direction.

- Calculate the average thrust on the rocket due to the rocket engine.
- Compare the average thrust to the peak thrust. Explain why the average thrust is so much smaller than the peak thrust.
- If the thrust by the rocket engine on the rocket is the only force acting on the rocket, then what will be the change in the rocket's momentum during the time interval from $t=0$ to $t=1.24$ s?
- Neglect the mass change due to the ejected gas. What is the maximum speed the rocket can reach?
- Estimate the maximum height the rocket could reach.