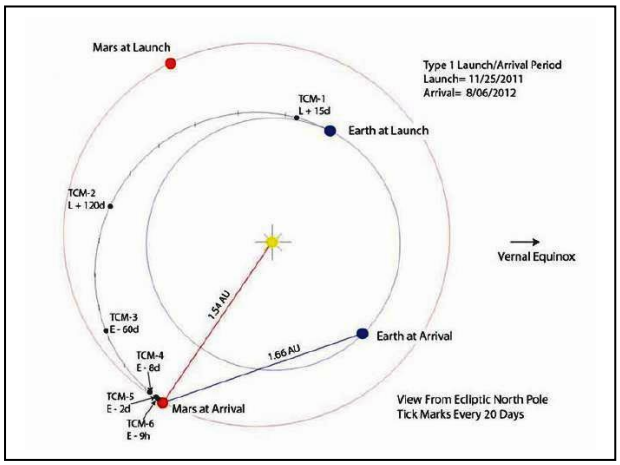


The Mars Science Laboratory was launched from Cape Canaveral on November 26, 2011 for a 251-day journey to Mars along an orbital path 567 million kilometers in length. The path is along a portion of an elliptical orbit called a Hohmann Transfer Orbit.

Hohmann Transfer Orbits require the least amount of fuel to transfer a spacecraft from Earth's orbit around the sun to the orbit of Mars.

A Hohmann Transfer Orbit to Mars has a perihelion distance of 1.0 Astronomical Units, and an aphelion distance equal to the distance of Mars from the sun at the time of interception, which for August 6, 2012 is 1.5 Astronomical Units. One Astronomical Units (1 AU) equals 149 million km. One focus of the transfer orbit is located on the sun, as are the elliptical orbits of all the other planets. The relationship between the aphelion and perihelion distances, A and P, and the semi-major axis, A, and eccentricity, e, of the corresponding ellipse is given by

$P = a - c \qquad A = a + c$

where a is the semi-major axis and also the semi-minor axis is $b = (a^2 - c^2)^{1/2}$

Problem 1 – For the desired transfer orbit, what is the equation of the required elliptical orbit in standard form?

Problem 2 – From the diagram above, where would Earth be in its orbit if the spacecraft could complete its original transfer orbit and attempt to return to Earth?

Problem 3 - To the proper number of significant figures, what is the average speed of the Mars Science Laboratory spacecraft in its journey to Mars A) in kilometers/hr? B) miles/hour?

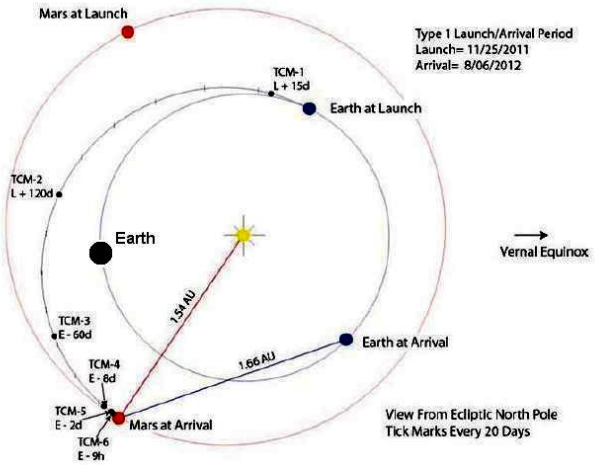
Problem 1 – For the desired transfer orbit, what is the equation of the required elliptical orbit in standard form?

Answer: The major axis has a total length of 1.0 + 1.0 + 0.5 = 2.5 AU, so a = 2.5/2 = 1.25 AU. Then from P = a – c and A = a + c we have 1.0 = 1.25 –c and 1.5 = 1.25 + c so that c = 0.25 AU. Then b = $(1.25^2 - 0.25^2)^{1/2}$ = 1.2 AU. Then from the standard form for an ellipse we get:

$$1 = \frac{x^2}{(1.25)^2} + \frac{y^2}{(1.2)^2}$$

Problem 2 – From the diagram above, where would Earth be in its orbit if the spacecraft could complete its original transfer orbit and attempt to return to Earth?

Answer: By symmetry, the dot on the orbit for Earth on August 6, 2012 would have to move an equal distance to its journey since November 25, 2011, which would place it near the indicated point in the diagram below:



Problem 3 - To the proper number of significant figures, what is the average speed of the Mars Science Laboratory spacecraft in its journey to Mars A) in kilometers/hr? B) miles/hour?

Answer: The 567 million km journey will take 251 days, so the average speed will be A) 567 million km/251 days = 2.26 million km/day or **94,200 km/hr** B) **58,400 miles/hr**. (since 1 km = 0.62 miles)