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Space Flight

Countdown for the Future

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ter, an effect that can be experienced in a car rounding a curve at great speed.

It is this centrifugal force, radially directed out- or upward from the orbital center, that is, from the earth's center, which supports the satellite, keeps it in a state of equilibrium with its weight and prevents the satellite from falling back to earth.

This centrifugal force acts on the satellite in exactly the same way as the supporting force exerted by the wings on an aircraft, with the only difference that the satellite meets no resistance in the direction of flight and therefore no longer needs a propellant force.

The entire procedure can best be illustrated by a simple experiment: If a stone is whirled around at the end of a cord, it pulls out on the cord, and the cord, due to the centrifugal force, becomes taut. The tension in the cord corresponds to the weight of the satellite in a circular orbit around the earth.

In our observations we have increased the initial velocity of our moving body step by step, from 25 m/sec to 1000 m/sec and then to 8000 m/sec.

If we should go one step further and increase the initial velocity to over 11,200 m/sec, then Kepler's ellipses are transformed into parabolas and furthermore into hyperbolas, hence, are no longer closed curves but curves whose segments point into infinity.

Along these segments the space vehicle leaves the narrow domain of the terrestrial neighborhood and moves into the depth of space of our solar system to be subjected there predominantly to the gravitational force of the sun, until it approaches other celestial bodies in the solar system, for instance, the moon, Mars or Venus, to be subjected there to their respective gravitational pulls.

INTERPLANETARY SPACE FLIGHT

Our solar system, with its nine planets as known up to now, can be represented as a flat disk whose radius is 6 billion kilometers. All planets orbit around the sun in the same direction on elliptical paths and are held in space by the solar field of gravity.

The innermost planet Mercury completes its orbit around the sun in 88 days; the earth completes its solar orbit in one year and the outermost planet Pluto in 248 years.

Our nearest inner neighbor among the planets, Venus, completes its orbit around the sun in 225 days and approaches the earth as closely as 38.6 million kilometers, approximately 100 times the distance earth-moon.

Our nearest outer neighbor among the planets, Mars, completes its orbit around the sun in 687 days and approaches the earth as closely as 53.7 million kilometers, approximately 140 times the distance earth-moon.

To transfer a spacecraft from one planetary orbit to another with minimum energy expenditure, on paths free of inertia, requires an elliptical trajectory which at both ends of the major axis is cotangential with the almost circular departure and target orbits—the so-called Hohmann ellipse.

The traveling time over one-half of a Hohmann ellipse is somewhere in the middle between the half-periods needed by the departure and target planets to orbit around the sun.

It takes approximately 147 days to travel from the earth to Venus, 263 days from the earth to Mars, or more generally, about half a year's time to travel to the neighboring planets, hence, half the time it takes the earth to orbit once around the sun.

On this basis, the traveling periods to the outer planets are correspondingly very long; for instance, 62 years to Pluto.

It is also obvious that such a journey cannot be undertaken at any old time, but only when the planetary constellations are such that the target planet at the end of the one-way journey is actually in the spacecraft's path. Likewise, a certain planetary orbital position is required for the return trip.

The farther remote the planets are from the sun, the smaller the velocities of the planets in their orbits around the sun. In the case of Mercury the velocity is 47.9 km/sec, for Venus 35.1 km/sec, earth 29.8 km/sec, Mars 24.1 km/sec and Pluto only 4.7 km/sec.

Allowance must be made for differences in orbital velocities in interplanetary flights.

Since, in addition, the Hohmann ellipses are cotangential to the inner-planetary orbits on their inside and to the outer-planetary orbits on their outside, the radius of curvature of the Hohmann ellipse at the point where it touches on the orbit of an inner planet is larger