JULIAN DATES

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Reference: Carroll, Bradley W. & Ostlie, Dale A. (2007), *An Introduction to Modern Astrophysics*, 2nd Edition; Pearson Education - Chapter 1, Problem 1.7.

The various units commonly used to measure the passage of time, such as days, weeks, months and years, are not conducive to simple calculations since such quantities as determining the number of days between two dates are not easy to calculate. In astronomy, most time calculations refer to the time *difference* between two events (for example, the orbital period of a planet or the period of variability of a star), so a method of specifying time that makes such differences easy to calculate is preferred.

The most common such system is the *Julian date*, in which each day, starting from noon Universal Time (UT or Greenwich Mean Time (GMT), which is the time zone used in the UK during the winter months) on January 1, 4713 BC, is numbered sequentially. The historic reason for this choice of starting date relies on choosing some rather obscure periods (one of which is a 15 year cycle the Romans used for calculating land tax), and isn't important in astronomy, but if you're interested, I'll refer you to the Wikipedia article.

The advantage of using Julian dates is, of course, that if the JD values for two events are known, the time between these events is just the difference in JDs. Of course, if we know the *calendar* date of an event, it's a bit of a pain to calculate the corresponding JD, but online converters exist, such as this one provided by the US Naval Observatory.

In order to calculate a JD for a date near to the present, it's useful to know the JD for a reference date in our current era. The JD of noon UT January 1, 2000 is

$$JD2000 = 2451545.0 \tag{1}$$

The JD of a time of day other than noon is calculated by adding on the fraction of a day since noon that has elapsed, so that midnight on January 2, 2000 (that is, 0:00 hours on January 2) is 2451545.5.

For a particular date such as July 14, 2006, 16:15 hours UT, we can work out the JD starting with JD2000 by counting the number of days since JD2000 (remembering to take leap years into account). The period from Jan

1, 2000 to Jan 1, 2006 includes 2 leap years (2000 and 2004) so there are $6 \times 365 + 2 = 2192$ days between these dates. Between noon Jan 1, 2006 and noon July 14, 2006, there are $31 + 28 + 31 + 30 + 31 + 30 + 13 = 194$ full days, so we're now up to $2192 + 194 = 2386$ complete days since Jan 1, 2000. The time from 12:00 to 16:15 is $4.25/24 = 0.177083$ days, so the JD of July 14, 2006, 16:15 hours UT is

$$JD = JD2000 + 2386 + 0.177083 = 2453931.177083 \tag{2}$$

There are several variants of the Julian date that are sometimes used. The Modified Julian Date (MJD) is defined as

$$MJD \equiv JD - 2400000.5 \tag{3}$$

which is equivalent to setting the starting date of $MJD = 0.0$ at 0h November 17, 1858 (thus the MJD starts at midnight UT rather than noon). Historically, the MJD was introduced in 1957 to allow the computers of the day (with very limited memory) to track the orbit of the first artificial satellite, Sputnik. Reducing the size of the numbers allowed the computer to handle the calculations. Thus the MJD of July 14, 2006, 16:15 hours UT is

$$MJD = 2453931.177083 - 2400000.5 = 53930.677083 \tag{4}$$

Other variants include the Reduced JD, with starting date of 12:00 on November 16, 1858, Truncated JD (0:00, May 24, 1968), Dublin JD (12:00, December 31, 1899) and Chronological JD (0:00, January 1, 4713 BC, but adjusted for local time zone). All these variants, however, still number days sequentially from their starting date so they are all equally useful for calculating time differences between events.