Archive-name: space/math

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References that have been frequently recommended on the net are:

"Fundamentals of Astrodynamics" Roger Bate, Donald Mueller, Jerry White

1971, Dover Press, 455pp $8.95 (US) (paperback). ISBN 0-486-60061-0

NASA Spaceflight handbooks (dating from the 1960s)

SP-33 Orbital Flight Handbook (3 parts)

SP-34 Lunar Flight Handbook   (3 parts)

SP-35 Planetary Flight Handbook (9 parts)

These might be found in university aeronautics libraries or ordered

through the US Govt. Printing Office (GPO), although more

information would probably be needed to order them.

M. A. Minovitch, _The Determination and Characteristics of Ballistic

Interplanetary Trajectories Under the Influence of Multiple Planetary

Attractions_, Technical Report 32-464, Jet Propulsion Laboratory,

Pasadena, Calif., Oct, 1963.

The title says all. Starts of with the basics and works its way up.

Very good. It has a companion article:

M. Minovitch, _Utilizing Large Planetary Perubations for the Design of

Deep-Space Solar-Probe and Out of Ecliptic Trajectories_, Technical

Report 32-849, JPL, Pasadena, Calif., 1965.

You need to read the first one first to realy understand this one.

It does include a _short_ summary if you can only find the second.

Contact JPL for availability of these reports.

"Spacecraft Attitude Dynamics", Peter C. Hughes 1986, John Wiley and

Sons.

"Celestial Mechanics: a computational guide for the practitioner",

Lawrence G. Taff, (Wiley-Interscience, New York, 1985).

Starts with the basics (2-body problem, coordinates) and works up to

orbit determinations, perturbations, and differential corrections.

Taff also briefly discusses stellar dynamics including a short

discussion of n-body problems.

More net references:

Van Flandern & Pullinen, _Low-Precision Formulae for Planetary

Positions_, Astrophysical J. Supp Series, 41:391-411, 1979. Look in an

astronomy or physics library for this; also said to be available from

Willmann-Bell.

Gives series to compute positions accurate to 1 arc minute for a

period + or - 300 years from now. Pluto is included but stated to

have an accuracy of only about 15 arc minutes.

Multiyear Interactive Computer Almanac (MICA), produced by the US

Naval Observatory. Valid for years 1990-1999. $55 ($80 outside US).

Available for IBM (order #PB93-500163HDV) or Macintosh (order

#PB93-500155HDV). From the NTIS sales desk, (703)-487-4650. I believe

this is intended to replace the USNO's Interactive Computer Ephemeris.

Interactive Computer Ephemeris (from the US Naval Observatory)

distributed on IBM-PC floppy disks, $35 (Willmann-Bell). Covers dates

"Planetary Programs and Tables from -4000 to +2800", Bretagnon & Simon

1986, Willmann-Bell.

Floppy disks available separately.

"Fundamentals of Celestial Mechanics" (2nd ed), J.M.A. Danby 1988,

Willmann-Bell.

A good fundamental text. Includes BASIC programs; a companion set of floppy disks is available separately.

"Astronomical Formulae for Calculators" (4th ed.), J. Meeus 1988, Willmann-Bell.

"Astronomical Algorithms", J. Meeus 1991, Willmann-Bell.

If you actively use one of the editions of "Astronomical Formulae for Calculators", you will want to replace it with "Astronomical Algorithms". This new book is more oriented towards computers than calculators and contains formulae for planetary motion based on modern work by the Jet Propulsion Laboratory, the U.S. Naval Observatory, and the Bureau des Longitudes. The previous books were all based on formulae mostly developed in the last century.

Algorithms available separately on diskette.

"Practical Astronomy with your Calculator" (3rd ed.), P. Duffett-Smith 1988, Cambridge University Press.

"Orbits for Amateurs with a Microcomputer", D. Tattersfield 1984, Stanley Thornes, Ltd.

Includes example programs in BASIC.

"Orbits for Amateurs II", D. Tattersfield 1987, John Wiley & Sons.

"Astronomy / Scientific Software" - catalog of shareware, public domain, and commercial software for IBM and other PCs. Astronomy software includes planetarium simulations, ephemeris generators, astronomical databases, solar system simulations, satellite tracking programs, celestial mechanics simulators, and more.

Andromeda Software, Inc.

P.O. Box 605

Amherst, NY 14226-0605

Astrogeologist Gene Shoemaker proposes the following formula, based on

studies of cratering caused by nuclear tests.

D = S S c K W   : crater diameter in km

S = (g /g)   : gravity correction factor for bodies other than

g e t   Earth, where g = 9.8 m/s^2 and gis the surface

e   t

gravity of the target body. This scaling is

cited for lunar craters and may hold true for

other bodies.

S = (p / p)   : correction factor for target density p ,

p a   t   t

p = 1.8 g/cm^3 for alluvium at the Jangle U

a

crater site, p = 2.6 g/cm^3 for average

rock on the continental shields.

C   : crater collapse factor, 1 for craters <= 3 km

in diameter, 1.3 for larger craters (on Earth).

K   : .074 km / (kT TNT equivalent)

n   empirically determined from the Jangle U

nuclear test crater.

W = pi * d* delta * V / (12 * 4.185 * 10)

: projectile kinetic energy in kT TNT equivalent

given diameter d, velocity v, and projectile

density delta in CGS units. delta of around 3

g/cm^3 is fairly good for an asteroid.

An RMS velocity of V = 20 km/sec may be used for Earth-crossing asteroids.

Under these assumptions, the body which created the Barringer Meteor Crater in Arizona (1.13 km diameter) would have been about 40 meters in diameter.

More generally, one can use (after Gehrels, 1985):

Asteroid   Number of objects Impact probability Impact energy

diameter (km)   (impacts/year)   (* 5*10^20 ergs)

assuming simple scaling laws. Note that 5*10^20 ergs = 13 000 tons TNT equivalent, or the energy released by the Hiroshima A-bomb.

References:

Gehrels, T. 1985 Asteroids and comets. _Physics Today_ 38, 32-41. [an excellent general overview of the subject for the layman]

Shoemaker, E.M. 1983 Asteroid and comet bombardment of the earth. _Ann. Rev. Earth Planet. Sci._ 11, 461-494. [very long and fairly technical but a comprehensive examination of the subject]

Shoemaker, E.M., J.G. Williams, E.F. Helin & R.F. Wolfe 1979 Earth-crossing asteroids: Orbital classes, collision rates with Earth, and origin. In _Asteroids_, T. Gehrels, ed., pp. 253-282, University of Arizona Press, Tucson.

Cunningham, C.J. 1988 _Introduction to Asteroids: The Next Frontier_ (Richmond: Willman-Bell, Inc.) [covers all aspects of asteroid studies and is an excellent introduction to the subject for people of all experience levels. It also has a very extensive reference list covering essentially all of the reference material in the

field.]

Two easy-to-find sources of map projections are the "Encyclopaedia Brittanica", (particularly the older volumes) and a tutorial appearing in _Graphics Gems_ (Academic Press, 1990). The latter was written with simplicity of exposition and suitability of digital computation in mind (spherical trig formulae also appear, as do digitally-plotted examples).

More than you ever cared to know about map projections is in John Snyder's USGS publication "Map Projections--A Working Manual", USGS Professional Paper 1395. This contains detailed descriptions of 32 projections, with history, features, projection formulas (for both spherical earth and ellipsoidal earth), and numerical test cases. It's a neat book, all 382 pages worth. This one's $20.

You might also want the companion volume, by Snyder and Philip Voxland, "An Album of Map Projections", USGS Professional Paper 1453. This contains less detail on about 130 projections and variants. Formulas are in the back, example plots in the front. $14, 250 pages.

You can order these 2 ways. The cheap, slow way is direct from USGS: Earth Science Information Center, US Geological Survey, 507 National Center, Reston, VA 22092. (800)-USA-MAPS. They can quote you a price and tell you where to send your money. Expect a 6-8 week turnaround time.

A much faster way (about 1 week) is through Timely Discount Topos, (303)-469-5022, 9769 W. 119th Drive, Suite 9, Broomfield, CO 80021. Call them and tell them what you want. They'll quote a price, you send a check, and then they go to USGS Customer Service Counter and pick it up for you. Add about a $3-4 service charge, plus shipping.

A (perhaps more accessible) mapping article is:

R. Miller and F. Reddy, "Mapping the World in Pascal",

Byte V12 #14, December 1987

Contains Turbo Pascal procedures for five common map projections. A

demo program, CARTOG.PAS, and a small (6,000 point) coastline data

is available on CompuServe, GEnie, and many BBSs.

Some references for spherical trignometry are:

Spherical Astronomy, W.M. Smart, Cambridge U. Press, 1931.

A Compendium of Spherical Astronomy, S. Newcomb, Dover, 1960.

Spherical Astronomy, R.M. Green, Cambridge U. Press., 1985 (update

of Smart).

Spherical Astronomy, E Woolard and G.Clemence, Academic

Press, 1966.

"Computer Simulation Using Particles"

R. W. Hockney and J. W. Eastwood

(Adam Hilger; Bristol and Philadelphia; 1988)

"The rapid evaluation of potential fields in particle systems",

L. Greengard

MIT Press, 1988.

A breakthrough O(N) simulation method. Has been parallelized.

L. Greengard and V. Rokhlin, "A fast algorithm for particle

simulations," Journal of Computational Physics, 73:325-348, 1987.

"An O(N) Algorithm for Three-dimensional N-body Simulations", MSEE

thesis, Feng Zhao, MIT AILab Technical Report 995, 1987

"Galactic Dynamics"

J. Binney & S. Tremaine

(Princeton U. Press; Princeton; 1987)

Includes an O(N^2) FORTRAN code written by Aarseth, a pioneer in the field.

Hierarchical (N log N) tree methods are described in these papers:

A. W. Appel, "An Efficient Program for Many-body Simulation", SIAM Journal of Scientific and Statistical Computing, Vol. 6, p. 85,

Barnes & Hut, "A Hierarchical O(N log N) Force-Calculation Algorithm", Nature, V324 # 6096, 4-10 Dec 1986.

L. Hernquist, "Hierarchical N-body Methods", Computer Physics Communications, Vol. 48, p. 107, 1988.

If you just need to examine FITS images, use the ppm package (see the comp.graphics FAQ) to convert them to your preferred format. For more information on the format and other software to read and write it, see the sci.astro.fits FAQ.

The 6th Edition of the Unix operating system came with several software systems not distributed because of older media capacity limitations. Included were an ephmeris, a satellite track, and speech synthesis software. The ephmeris, sky(6), is available within AT&T and to sites possessing a Unix source code license. The program is regarded as Unix source code. Sky is <0.5MB. Send proof of source code license to

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To generate 3D coordinates of astronomical objects, first obtain an astronomical database which specifies right ascension, declination, and parallax for the objects. Convert parallax into distance using the formula in part 6 of the FAQ, convert RA and declination to coordinates on a unit sphere (see some of the references on planetary positions and spherical trignometry earlier in this section for details on this), and scale this by the distance.

Two databases useful for this purpose are the Yale Bright Star catalog (sources listed in FAQ section 3) or "The Catalogue of Stars within 25 parsecs of the Sun" (in pub/SPACE/FAQ/stars.data and stars.doc on ames.arc.nasa.gov).

NEXT: FAQ #5/15 - References on specific areas