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JavaScript Travel Time Simulator

How do we calculate the travel time arrays?

		d →						
		33.00	63.38	126.76	190.14	253.52	316.90	380.28
1s/1°	**0.00**	**-5.400**	**-13.500**	**-21.400**	**-29.100**	**-36.600**	**-43.900**	**-51.100**
	ED 1.00	-5.400	-13.490	-21.390	-29.090	-36.590	-43.890	-51.080
	2.00	-5.400	-13.480	-21.380	-29.080	-36.580	-43.880	-51.060
	3.00	-5.400	-13.470	-21.370	-29.070	-36.570	-43.870	-51.040
	4.00	-5.400	-13.460	-21.360	-29.060	-36.560	-43.860	-51.020
	5.00	-5.400	-13.450	-21.350	-29.050	-36.550	-43.850	-51.000
	6.00	-5.400	-13.440	-21.340	-29.040	-36.540	-43.840	-50.980
	7.00	-5.400	-13.430	-21.330	-29.030	-36.530	-43.830	-50.960
	8.00	-5.400	-13.420	-21.320	-29.020	-36.520	-43.820	-50.940
	9.00	-5.400	-13.410	-21.310	-29.010	-36.510	-43.810	-50.920
	10.00	**-5.400**	**-13.400**	**-21.300**	**-29.000**	**-36.500**	**-43.800**	**-50.900**
1.8s/1°	11.00	-5.400	-13.400	-21.283	-28.967	-36.450	-43.750	-50.850
	12.00	-5.400	-13.400	-21.267	-28.933	-36.400	-43.700	-50.800
	13.00	-5.400	-13.400	-21.250	-28.900	-36.350	-43.650	-50.750
	14.00	-5.400	-13.400	-21.233	-28.867	-36.300	-43.600	-50.700
	15.00	-5.400	-13.400	-21.217	-28.834	-36.250	-43.550	-50.650
	16.00	**-5.400**	**-13.400**	**-21.200**	**-28.800**	**-36.200**	**-43.500**	**-50.600**

The table above is a section of the interpolated allowance table for PcS. The far left column is the dt/dΔ values so we can use the PcP allowance table. This column is only used when we're dealing with a core phase that isn't PcP, PKP, SKS, or ScS. The bold values are directly from the JB allowance tables, while the rest of the values are interpolated using excel. This section shows epicentral distance (ED) from 0-16 degrees and focal depth from 33-380.28km.

	0.00	33.00	63.38	126.76	190.14	253.52	316.90	380.28
0.0	725.00	730.40	738.50	746.40	754.10	761.60	768.90	776.10
1.0	725.10	730.50	738.59	746.49	754.19	761.69	768.99	776.18
2.0	725.20	730.60	738.68	746.58	754.28	761.78	769.08	776.26
3.0	725.50	730.90	738.97	746.87	754.57	762.07	769.37	776.54
4.0	726.00	731.40	739.46	747.36	755.06	762.56	769.86	777.02
5.0	726.50	731.90	739.95	747.85	755.55	763.05	770.35	777.50
6.0	727.20	732.60	740.64	748.54	756.24	763.74	771.04	778.18
7.0	728.00	733.40	741.43	749.33	757.03	764.53	771.83	778.96
8.0	729.00	734.40	742.42	750.32	758.02	765.52	772.82	779.94
9.0	730.00	735.40	743.41	751.31	759.01	766.51	773.81	780.92
10.0	731.20	736.60	744.60	752.50	760.20	767.70	775.00	782.10
11.0	732.50	737.90	745.90	753.78	761.47	768.95	776.25	783.35
12.0	733.90	739.30	747.30	755.17	762.83	770.30	777.60	784.70
13.0	735.40	740.80	748.80	756.65	764.30	771.75	779.05	786.15
14.0	737.10	742.50	750.50	758.33	765.97	773.40	780.70	787.80
15.0	738.80	744.20	752.20	760.02	767.63	775.05	782.35	789.45
16.0	740.60	746.00	754.00	761.80	769.40	776.80	784.10	791.20

The JB allowance values above are subtracted from the surface focus condition (0.00km), to get the rest of the follow values for other focal depths.

How do we convert the focal depth values to kilometers?

The JB allowance tables show focal depth in time units, where there's surface, than 0.00 to 0.12. These were converted into kilometers to have more practical use. It is taken that the focal depths are given as fractions of the earth's radius below the continental crust. It is given that 0.00 is the average depth of the continental crust – given to be 33km (Jeffreys and Bullen, 1967). The rest of the values 0.01-0.12 are calculated as fractions of the remaining radius which is 6338km.

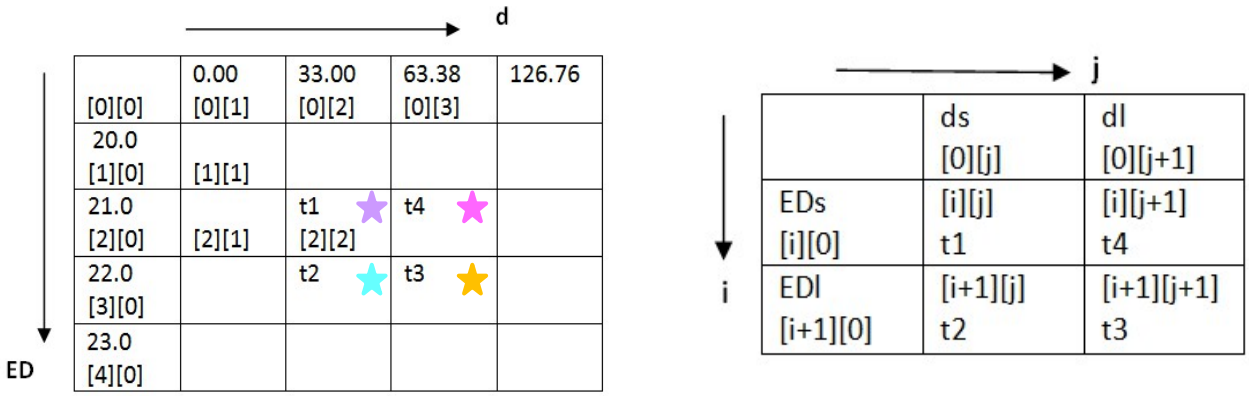
What is the formula used to calculate Epicentral Distance (ED)?

ED = (Math.acos((Math.cos(Math.PI/2-(Q1*Math.PI/180))*Math.cos(Math.PI/2-(S1*Math.PI/180)))+ (Math.sin(Math.PI/2-(Q1*Math.PI/180))*Math.sin(Math.PI/2-(S1*Math.PI/180))*Math.cos(Math.abs(Q2-S2)*Math.PI/180)))*180)/Math.PI;

As can be seen the equation follows the equation cos (c) = cos (a) cos (b) + sin (a) sin (b) cos (c), the reason why the coded version looks rather long is because JavaScript along with many other computer languages do trigonometric equations in radians and not degrees. The Q1 and S1 are the latitudes of the earthquake and station, while Q2 and S2 are the longitudes.

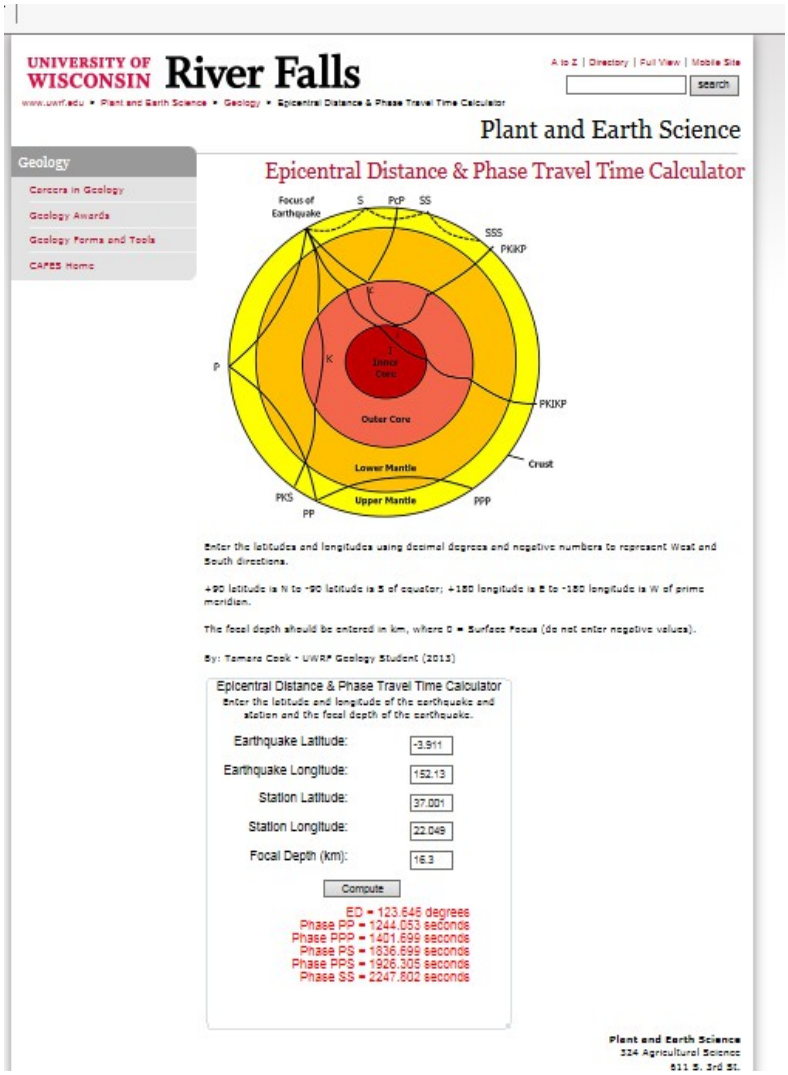
What is the formula used to do the bilinear interpolation?

tk = (((dl-d)*(EDl-ED))/((dl-ds)*(EDl-EDs)))*t1 + (((d-ds)*(EDl-ED))/((dl-ds)*(EDl-EDs)))*t4 + (((dl-d)*(ED-EDs))/((dl-ds)*(EDl-EDs)))*t2 + (((d-ds)*(ED-EDs))/((dl-ds)*(EDl-EDs)))*t3;



The table on the left shows the four quadrants t1, t2, t3, and t4. The numbers in [][], are to represent the code value for the element in the array for this example (20 degrees ED would not actually be [1][0] in an actual array but a later value than [1]). The schematic is just meant to show the numbering system. The table on the right shows all the values needed for bilinear interpolation equation and the coded value for each of those variables as well. The I and j are the values that are used in the for loops, where i is for ED values and j is for focal depth (d) values.

How can I find this website?
http://www.uwrf.edu/PES/Geology/EDPTT_Calculator.cfm



Example used:
*M6.5 – 32km N of Rabaul, Papua New Guinea Earthquake on April 23, 2013 14:42 UTC
Location: 3.911°S 152.127°E
Focal depth: 16.3km
http://earthquake.usgs.gov/earthquakes/map/

*Station Location
JUCM: University of California, Santa Cruz
37.00119°N 122.04850°W
http://www.isc.ac.uk/registries/

Source:
Jeffreys, H., and Bullen, K.E., 1967, Seismological Tables: London office of the British Association Burlington House, W.1