GEOL 460 Solid Earth Geophysics
Lab 3: Earthquake Seismology

Name: ____ Date: ___________

Part I. Make Your Own Seismogram

Step 1. Go to the Berkeley Seismological Laboratory's MAKE YOUR OWN SEISMOGRAM web site at:

http://quake.geo.berkeley.edu/bdsn/make_seismogram.html

Berkeley has a network of high quality seismographs throughout Northern California. Click on the Map link next to Available Stations to see where the stations are located. You can use them to look at small regional earthquakes large global ones and everything in between. Today we focus on teleseisms.

M 6.4 Sep 9, 2011 Vancouver Island earthquake

This earthquake occurred fall semester, 2011. It was a strike-slip earthquake in the Explorer plate, the northern sister of the Gorda plate. This is a remote area, and although the earthquake was widely felt on Vancouver Island and Southern British Columbia, it caused no damage.

Step 2. Making a seismogram:

The default setting is the Columbia station CMB. It is Berkeley's most sensitive station (in a tunnel in Sierra granite). The round circle next to LHZ (long period vertical) should also be selected. This will give you the best viewing for a teleseism (a large distant quake).

- Beginning date, time UTC, 2011/09/09, 19:00:00
- Ending date, time UTC, 2011/09/09, 21:00:00

Finally, you need to give the computer its plotting instructions. Use these settings:

- Compression Factor: 2
- Amplitude Scaling: 0.0007
- Pixels: 40
- Click the create plot box at the bottom

Step 3. Questions:

1. How much time is shown on the entire record that appears on your computer screen?
2. How much time is shown on a complete line?
3. How much time is between each vertical line?

Now try changing the settings to see how they affect the appearance of the record:

4. Go back to the previous screen. Change the compression factor to 1 and look at the seismogram. Now change it to 3. What does changing the compression factor do to the appearance of the seismogram?

5. Go back to the previous screen and try changing the pixels. How does this change the appearance of the seismogram?
6. Now adjust the amplitude scaling. How does this affect the seismogram?

So far you have been looking at the LHZ record. L stands for long period, H for high gain, and Z means the vertical component of motion. This instrument records up and down ground motion, and doesn't feel the horizontal components. You can easily switch to the other components by going back to the main page, and choose LHN or LHE under the Select a Channel heading. Keep all of the other settings as they were in question 1.

7. What differences do you see, if any, between the LHN and LHZ seismograms? LHN measures horizontal motion in the north – south orientation. Look at the character of the different pulses of energy (seismic phases). How do the initial P wave pulses compare? Does the larger second pulse appear the same on both records?
8. What differences do you see between the LHE and LHZ seismograms?
9. Does LHE look more like LHN or LHZ? Can you think of a reason why this is so?

Part II Locating earthquakes

There are two steps to this part. In the first you will locate a California earthquake using seismograms from the Berkeley Seismological laboratory. The second part involves identifying phases from a teleseismic recording and estimating epicentral angle.

***Please do not look up the pertinent information for your earthquake beforehand!!!

If you have never gone through an earthquake location exercise before, I recommend working through the "Virtual Seismologist" exercise at: http://www.sciencecourseware.com/VirtualEarthquake/

Step 1.

I have selected a number of Northern California earthquakes that were well recorded by the Berkeley Seismic Network. I will be giving out the time and date of the earthquakes in lab. I encourage you to work in teams of two.

You will use the Berkeley Seismographic Station's web site at:

http://quake.geo.berkeley.edu/bdsn/make_seismogram.html

Attached is a simplified California Travel-Time curve for estimating epicentral distance. Estimate the epicentral distance for each station above.

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How to start: Make a seismogram that covers the time above using the CMB station. You should see the event. Use the BroadBand Stations! Adjust the settings so that you can clearly see the record. You will probably need to look at all three components. BHZ will help you identify the onset of the P wave, BHE and BHN will give you the best view of S. (You should understand why this is so!) I have attached a page of examples. Read the arrival times to the nearest 1/2 second. Now try other stations in the Berkeley network and find at least 2 more (preferable 3) that give a good recording of the event. Make a table of your stations and your P and S wave arrival times.

Play around with the settings to see what different configurations do. You will need at least 3 stations to get the epicenter. I would prefer you use 4. Use the attached travel time curve to determine the epicentral distance from each station that you choose.

Once you have epicentral distances, use the base map and a compass to draw arcs from each station to triangulate the epicenter. Note: The arcs won't meet perfectly at a single point, but will overlap or underlap slightly. You should understand why!

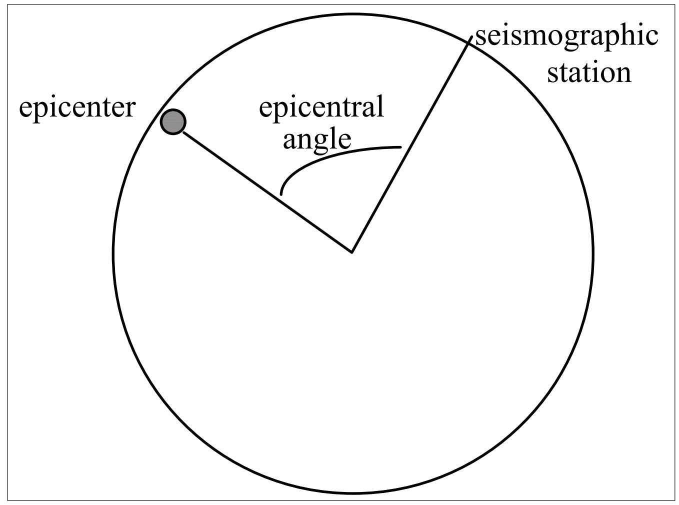
Now determine the Origin Time for your earthquake. You only need the data from one station to determine it.

Turn in your answer sheet and map with the arcs from each station drawn and a table summarizing the data from the seismograms. The table should include station name, P arrival time, S arrival time, S - P time, distance from epicenter. On the same sheet as the table, include your determination of the Origin Time. You DO NOT need to turn copies of the seismograms, travel time curves etc.

Step 2

I will give each of you a different record of a teleseism from your region. You will estimate the arrival times of different phases and use the global travel time curve to determine how far away (in degrees) the earthquake was from your station, and the origin time of the earthquake.

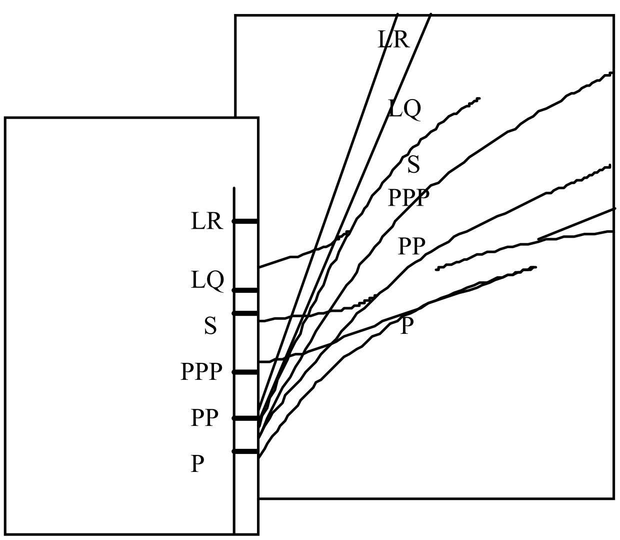
The travel time curve you worked with in part 1 above was quite simple. It gave only P and S wave arrival times and is applicable only to local California earthquakes. On the local scale when the distance between seismic stations and the epicenter is small, we can approximate the earth as flat. For earthquakes coming from far away - perhaps even on the other side of the earth - this approximation is no longer valid and we have to take the earth's shape into consideration. We also have to contend with the much more complex ray paths as they bounce off and are refracted by different layers deep within the earth. The result is the Jeffreys-Bullen travel time curve attached to this assignment. It's similar to the California travel time curve in that distance is still along the horizontal (or 'x' axis) and time is along the vertical axis. But that's pretty much where the resemblance ends. Distance is no longer in kilometers, but rather in degrees. Because the earth is round - we can no longer approximate distances by a straight line. Distances for teleseisms are measured by angles:

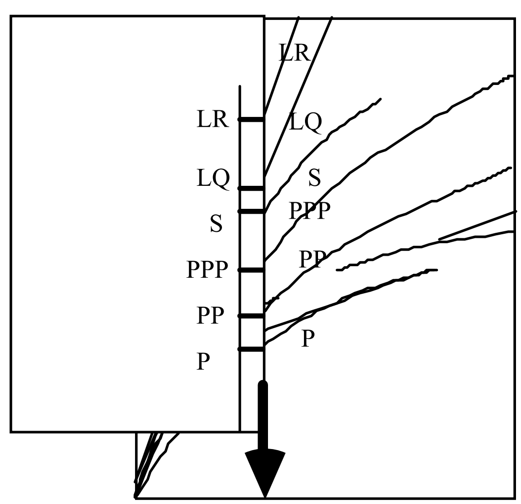


The epicentral angle shown above is the angle made by drawing a line between the focus of the earthquake and the center of the earth and the line between the seismographic station recording the earthquake and the earth's center. This angle varies between 0 and 180°. For example, consider the Loma Prieta earthquake located near Santa Cruz. The epicentral angle for a seismic station in Los Angeles was a little less than 5°. New York was about 37° away, Budapest, Hungary about 90° away and Cape Town, South Africa nearly on the opposite side of the earth - 160° away.

1. I have given you each copies of a different earthquake recorded on three long period seismographs The top record is from Z, the vertical instrument, the middle record is from the N (north-south horizontal) instrument and the bottom record is from E, the east - west horizontal instrument A number of different seismic phases are identified for you. You should be able to spot the P wave on the vertical instrument - it does not show up very well on the horizontals. The double or triple letter phases (PP, SKS etc.) are reflected arrivals, LQ is the Love wave and LR is the Rayleigh wave (L stands for long. On the edge of the tabulation sheet I have put a calibrated time scale. Mark and label the arrival times of each identified phase on this scale.

2. Determine the epicentral angle by looking at the illustration and following the steps below:





a) Keeping the edge of the calibrated time scale vertical (parallel to the time axis of the Jeffreys-Bullen travel time curve), match the P arrival time with the P curve on the travel time curve.

b) Now slide the time scale over the travel time curve until you get the best match between the arrival times on your calibrated time scale and the travel time curve. (Not all phases shown on the travel time curve will necessarily be present on the seismogram.)

c) Draw a line along the edge of your scale and see where it intersects the distance axis of the travel time curve. This intersection is the epicentral distance of the earthquake. Write the value on the answer sheet.

d) Now sketch this angle on the circle that represents the globe showing the relationship between the epicenter and the station.

e) Many of these seismograms show the PP phase on the record. Sketch in the path of PP on the circle too.

f) Determine the origin time of the earthquake.

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Answer Sheet: Part I. Make Your Own Seismogram

1. Time of the complete record ______________________
2. Time for a complete line ___________________________
3. Time between the vertical lines ____________________
4. Changing compression factor ____
5. Changing pixels____
6. Increasing amplitude scaling____
7. Difference between LHN and LHZ ____

   ____

8. Difference between LHE and LHZ ____

   ____

9. Does LHE look more like LHZ or LHN? __________________

   Why? ____

Answer Sheet: Part II Locating earthquakes

Step 1 California Earthquake Location

Date/time of event: ____

P & S wave travel times:

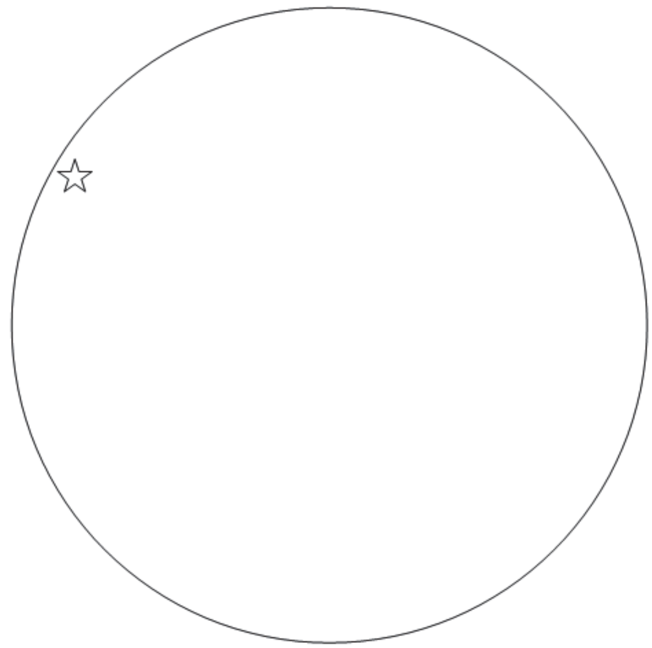
Station	P time	S time	S-P time	distance

Origin Time of Earthquake ______________________________________

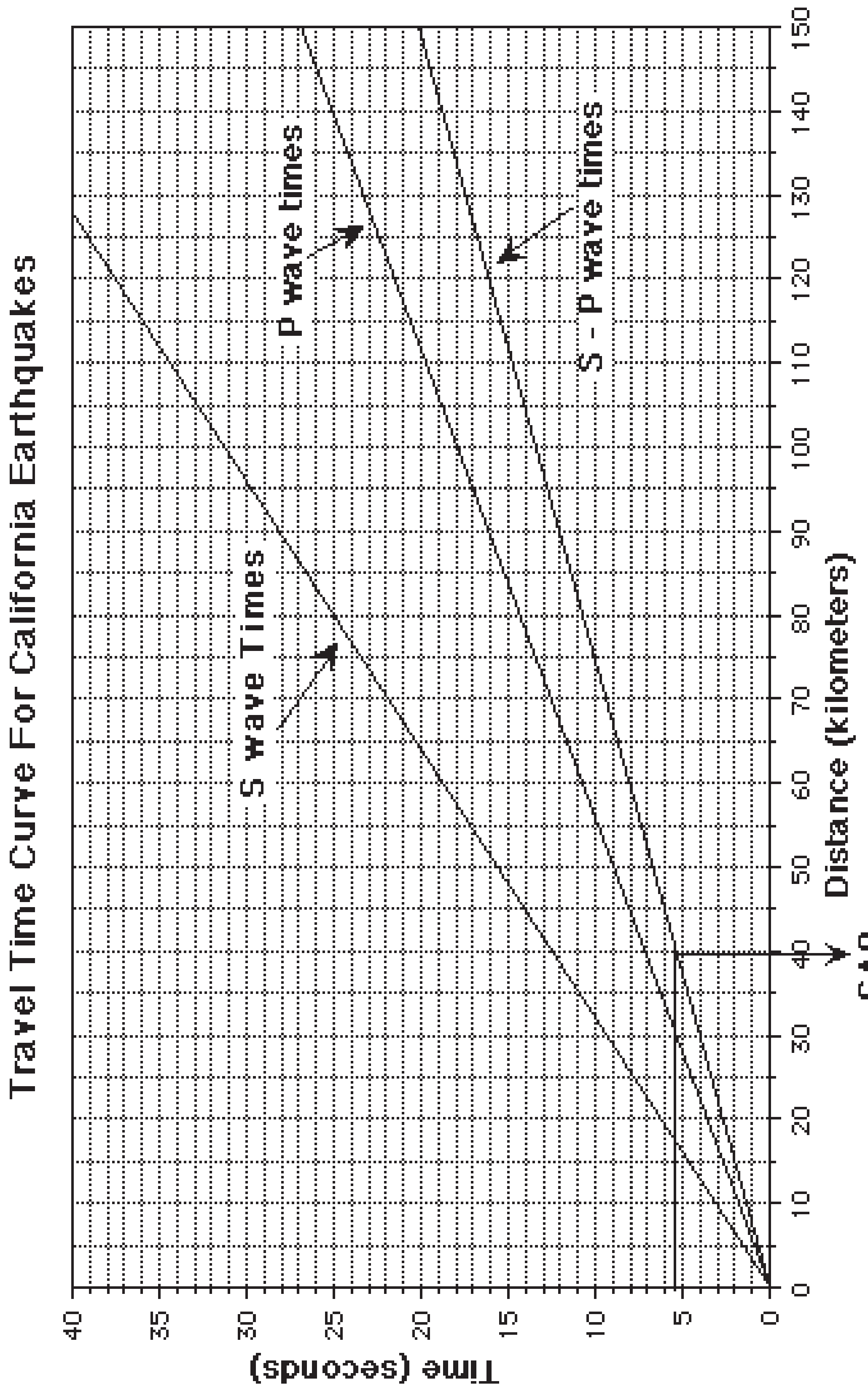
Step 2 Teleseisms

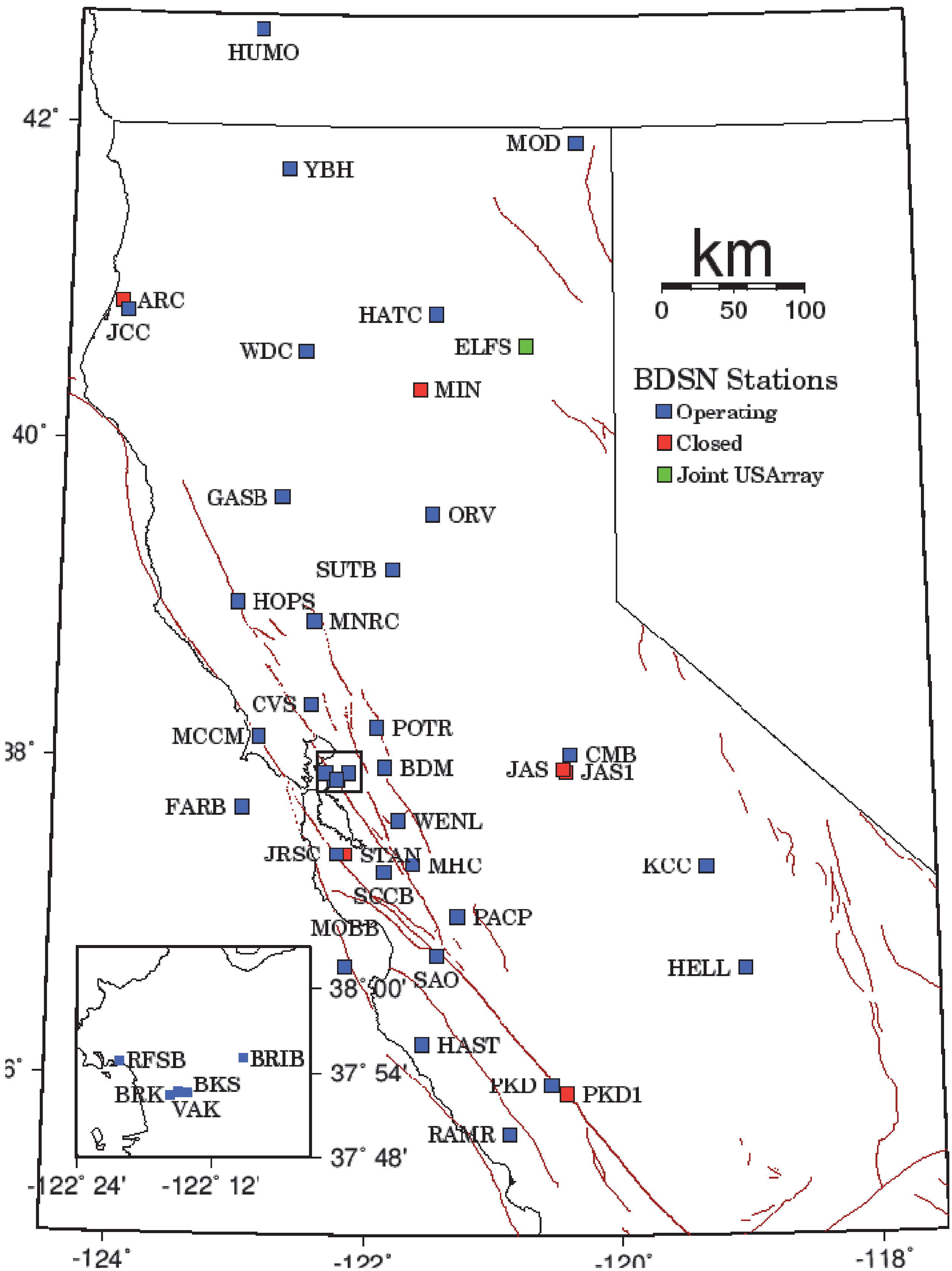
Date and # of Earthquake ________________________________

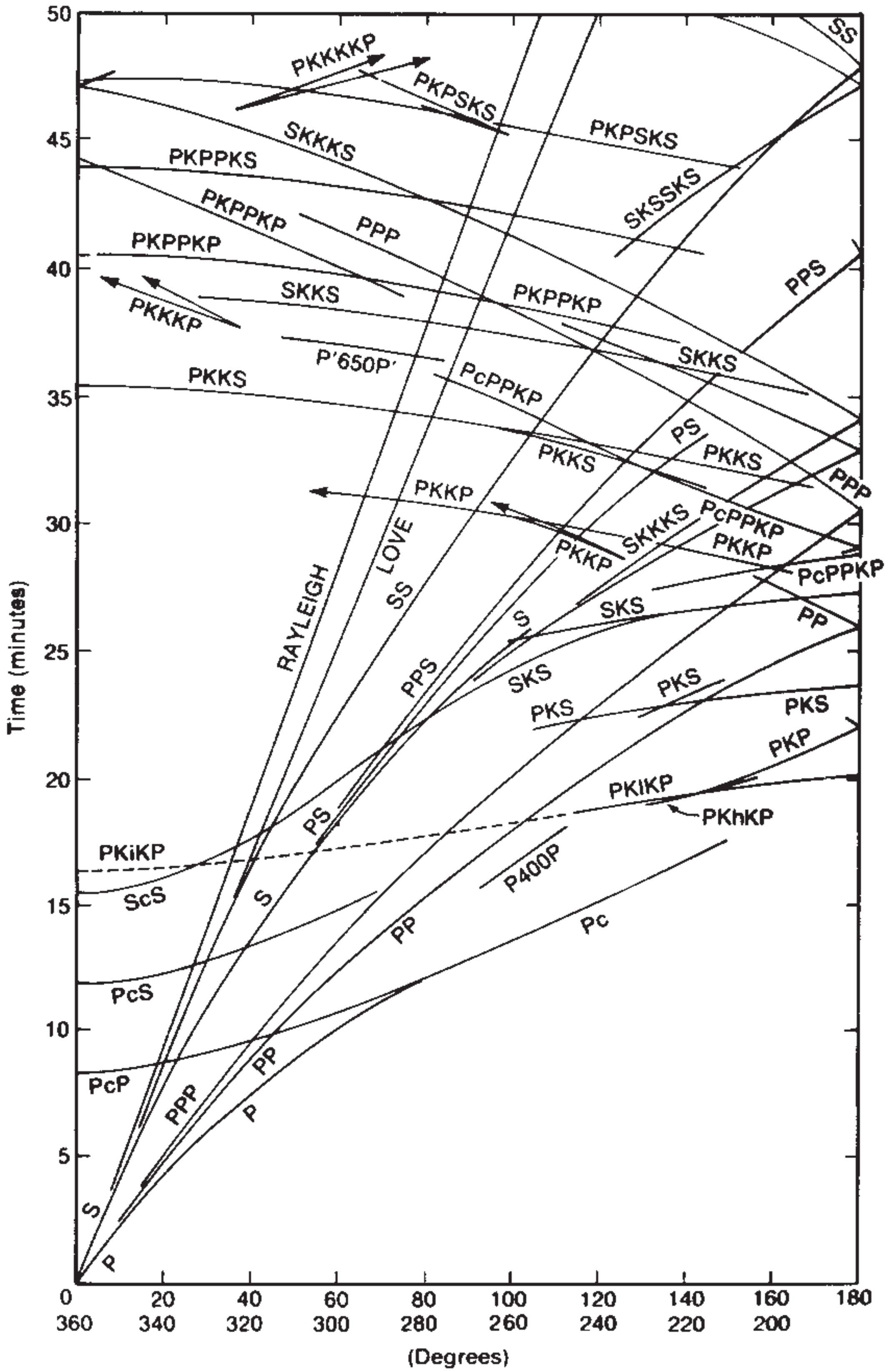
Phase	time



- Epicentral Angle: _______________
- Origin Time: ___________________
- Draw the epicentral angle from the source (star) to your station on the circle above.
- Draw the path of the PP phase between the source and the station.


Travel Time Curve For California Earthquakes
P wave times
S - P wave times
S wave Times
Time (seconds)
Distance (kilometers)
SAO
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150


HUMO
42˚
MOD
YBH
km
0
50
100
ARC
JCC
HATC
WDC
ELFS
MIN
BDSN Stations
Operating
Closed
Joint USArray
40˚
GASB
ORV
SUTB
HOPS
MNRC
CVS
POTR
MCCM
BDM
JAS
CMB
JAS1
FARB
WENL
JRSC
STAN
MHC
KCC
SCCB
PACP
MOBB
SAO
HELL
38˚ 00'
HAST
RFSB
BRIB
37˚ 54'
BRK
BKS
VAK
PKD
PKD1
RAMR
37˚ 48'
-122˚ 24'
-122˚ 12'
-124˚
-122˚
-120˚
-118˚


Time (minutes)
(Degrees)
0
5
10
15
20
25
30
35
40
45
50
0 20 40 60 80 100 120 140 160 180
360 340 320 300 280 260 240 220 200
P
S
PcP
PP
PPP
PcS
ScS
PKiKP
PS
PPS
RAYLEIGH
LOVE
SS
SKS
PKS
PKIKP
PKhKP
PKP
P400P
Pc
PKKP
SKKS
PcPPKP
PKKS
P'650P'
PKPPKP
SKKS
PKKKP
PPP
PKPPKS
SKKKS
PKKKKP
PKPSKS
SKSSKS
PPS