3.1 Plot the time history of acceleration and determine:

(a) The peak acceleration.

(b) The sustained maximum acceleration (3rd cycle and 5th cycle).

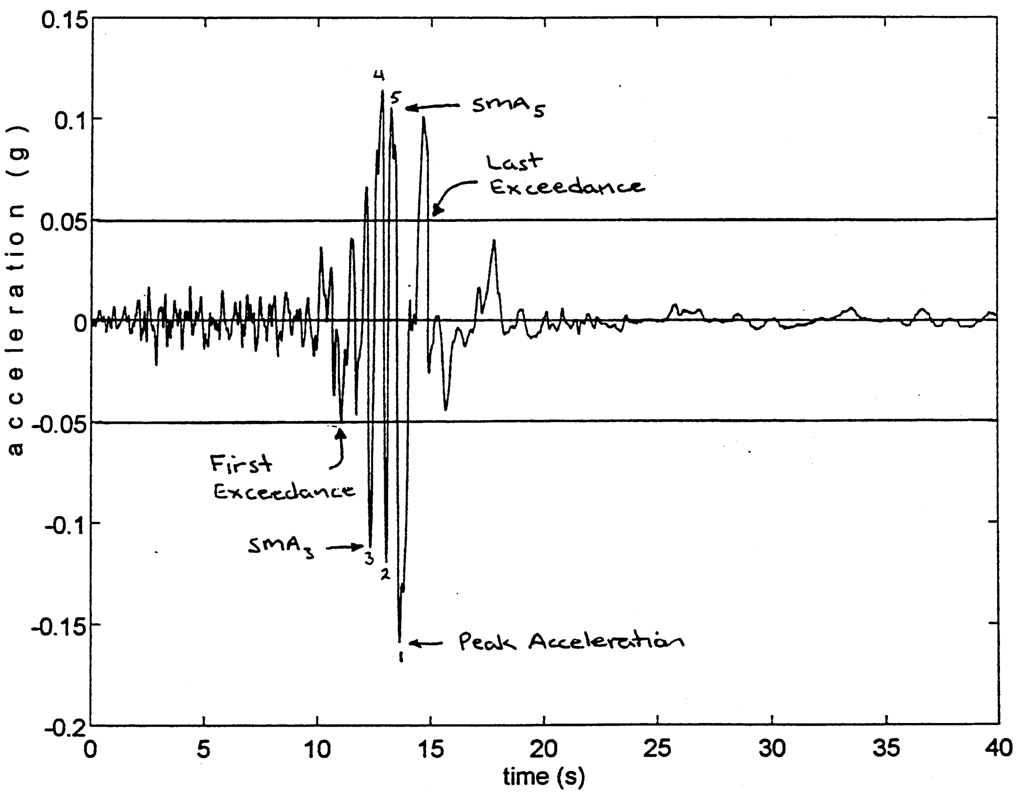
(c) The bracketed duration.

From plot of Treasure Island EW motion (Loma Prieta earthquake) shown below:

(a) PHA = 0.159 g

(b) Sustained maximum acceleration: 3rd cycle = 0.114 g
5th cycle = 0.105 g

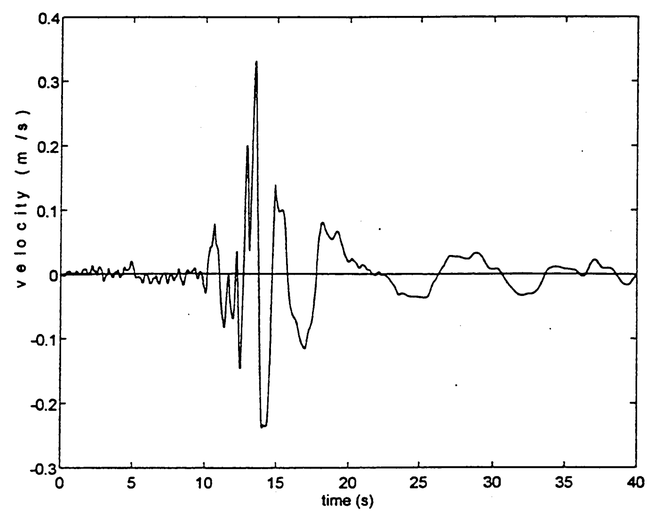
(c) Bracketed duration = 3.8 sec

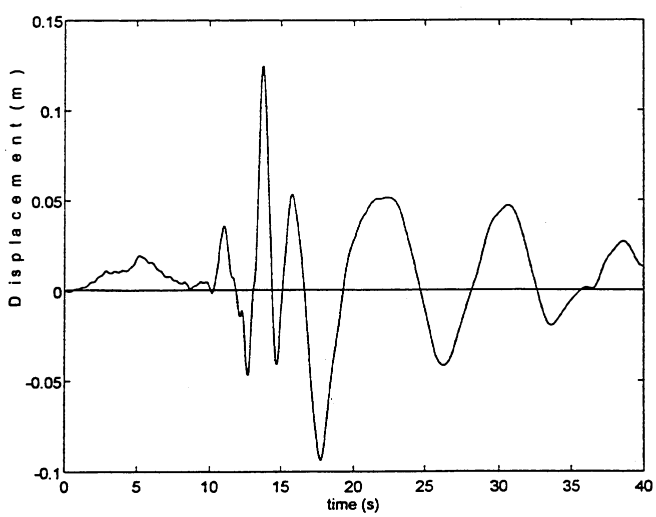


3.2 Integrate the time history of acceleration to produce time histories of velocity and displacement. Plot the time histories of velocity and displacement and determine the peak velocity and peak displacement.

Time histories are shown below. Peak values are:

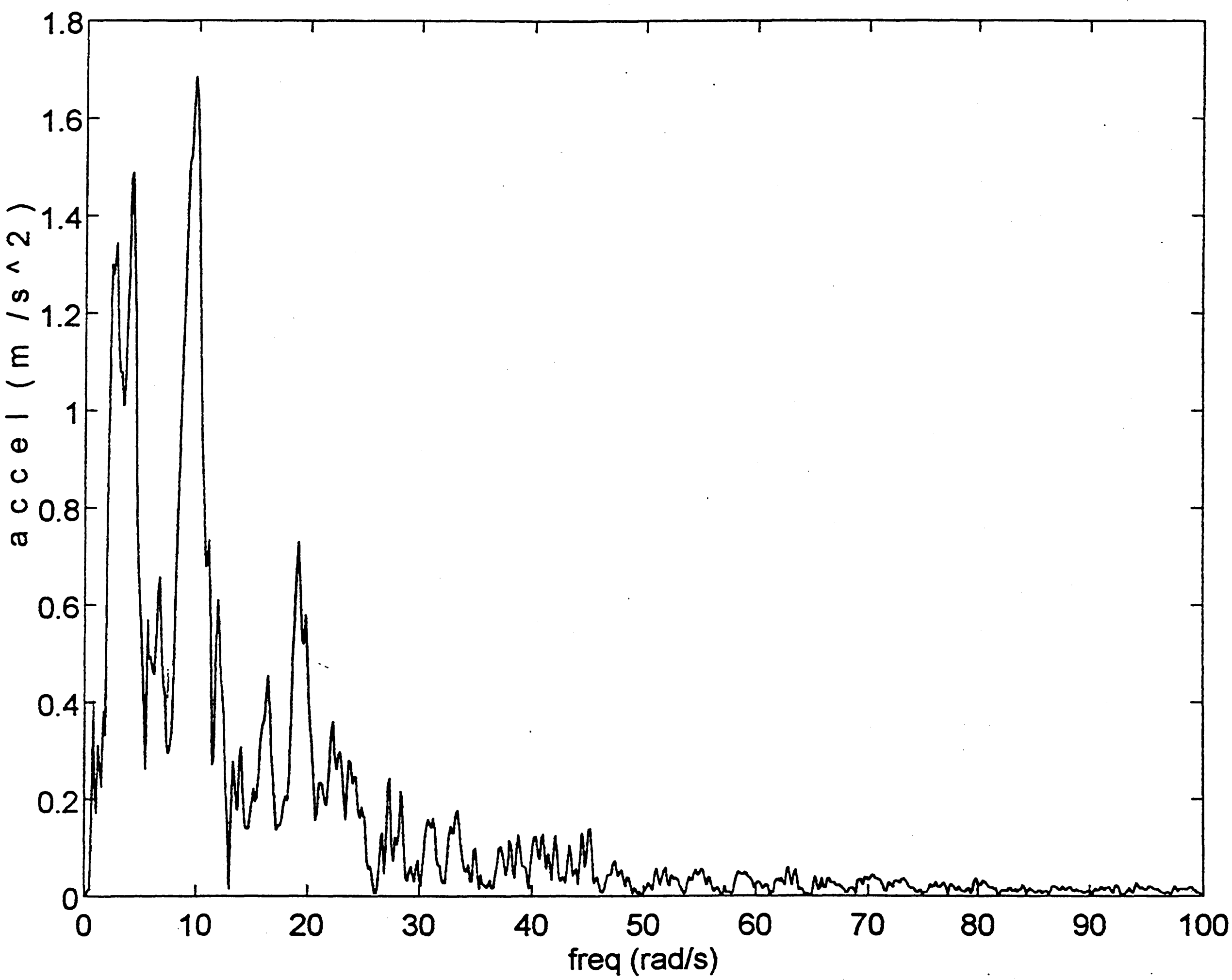
Peak velocity = 0.33 m/sec
Peak displacement = 12.7 cm





3.3 Compute and plot the Fourier amplitude spectrum of the strong motion record.

Plot of FAS (truncated below Nyquist frequency for better visibility of low frequency region) is shown below:

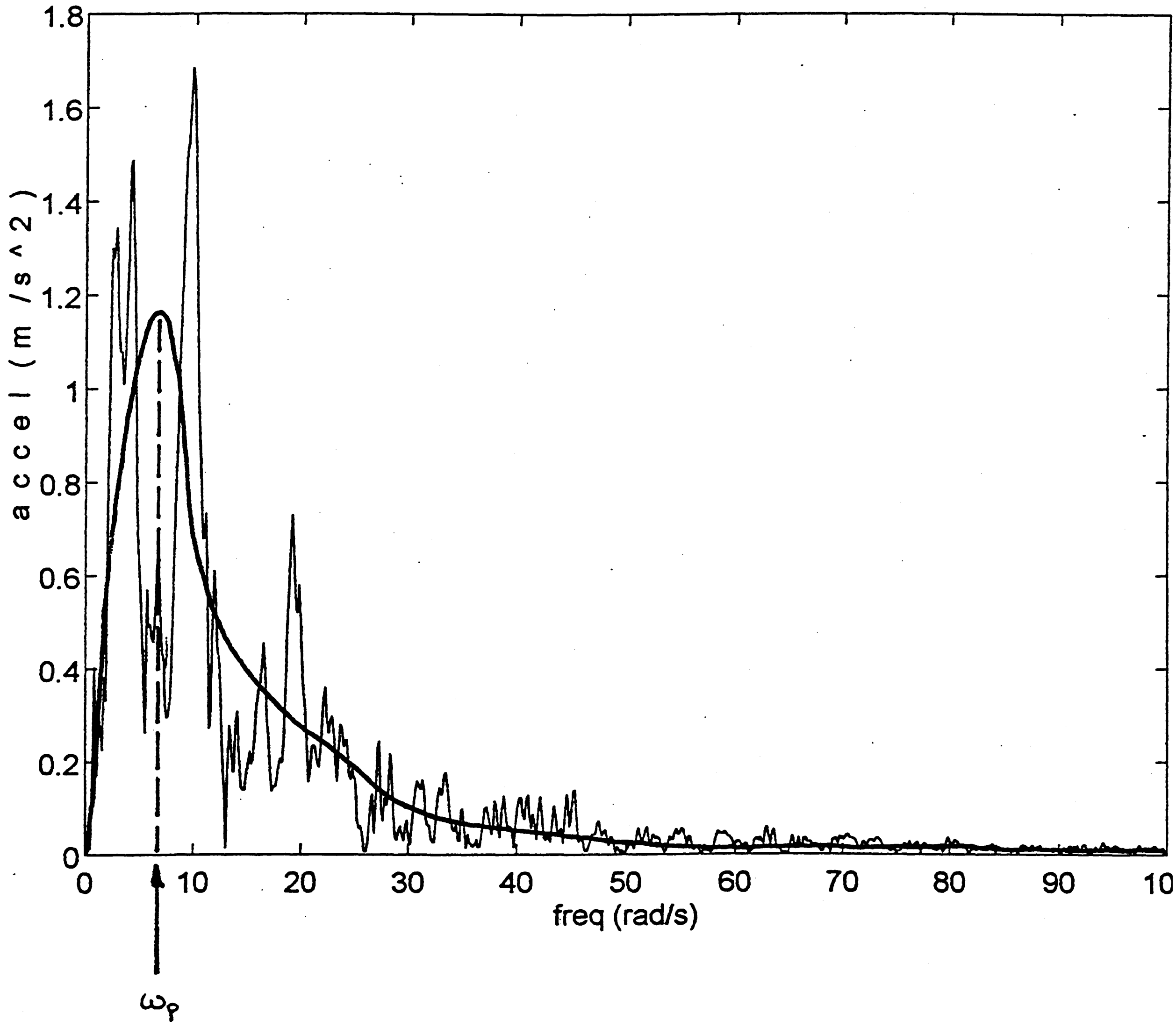


3.4 Determine the predominant period of the strong motion record.

By manual smoothing of FAS, $\omega_p \approx 6.6$ rad/sec

Then

$$T_p = \frac{2\pi}{\omega_p} \approx 0.96 \text{ sec}$$



3.5 Compute the rms acceleration for the strong motion record.

RMS acceleration

$$a_{rms} = \sqrt{\frac{1}{T_d}\int_0^{T_d} [a(t)]^2\, dt}$$

Evaluating integral numerically (trapezoidal rule) gives

$$a_{rms} = 0.73 \text{ m/sec}^2 = 0.074 \text{ g}$$

3.6 Compute the Arias intensity for the strong motion record.

Arias Intensity

$$I_a = \frac{\pi}{2g} \int_0^\infty [a(t)]^2 \, dt$$

Evaluating integral numerically (trapezoidal rule) gives

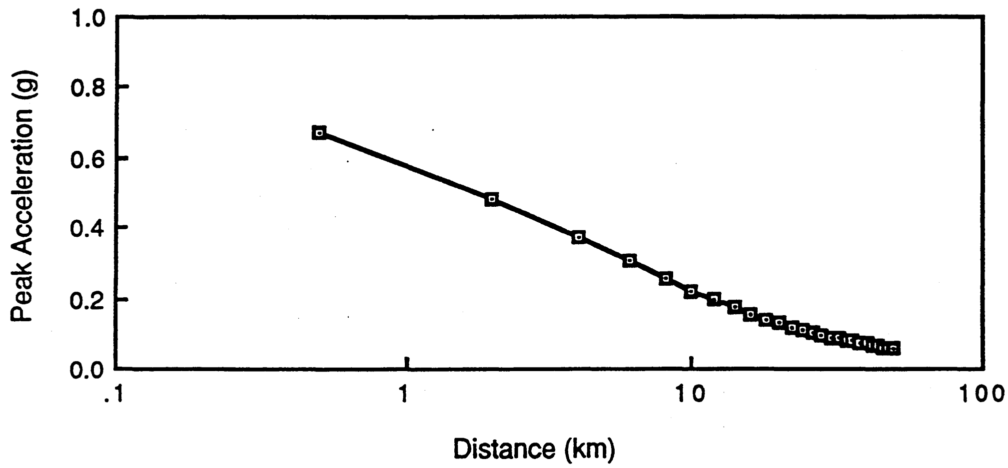
$$I_a = 0.36 \text{ m/sec}$$

3.7 Determine and plot the variations of peak horizontal acceleration with distance for a $M_w = 6.5$ earthquake using the attenuation relationship of Campbell (1981).

Plotting the relationship

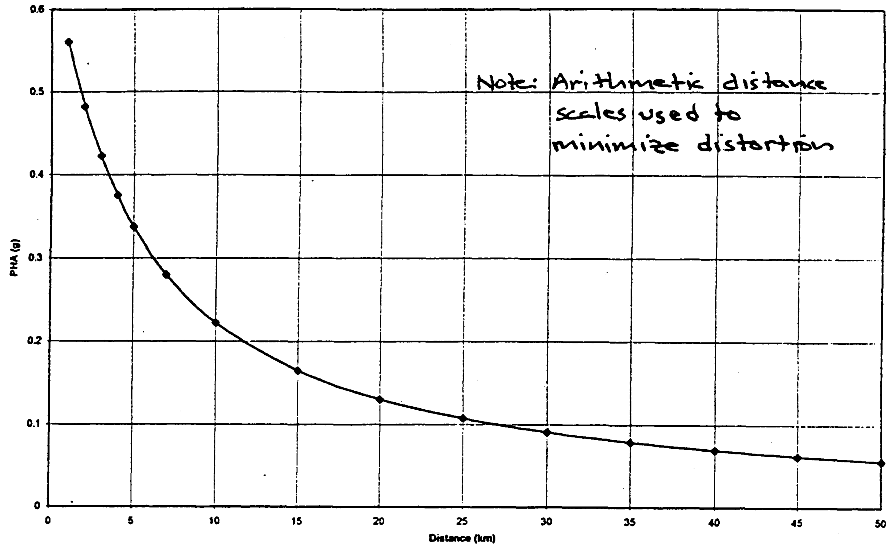
$$PHA\ (g) = \exp[-4.141 - 0.868M - 1.09 \ln[R + 0.0606 \exp(0.7M)]]$$

for $M = 6.5$ gives



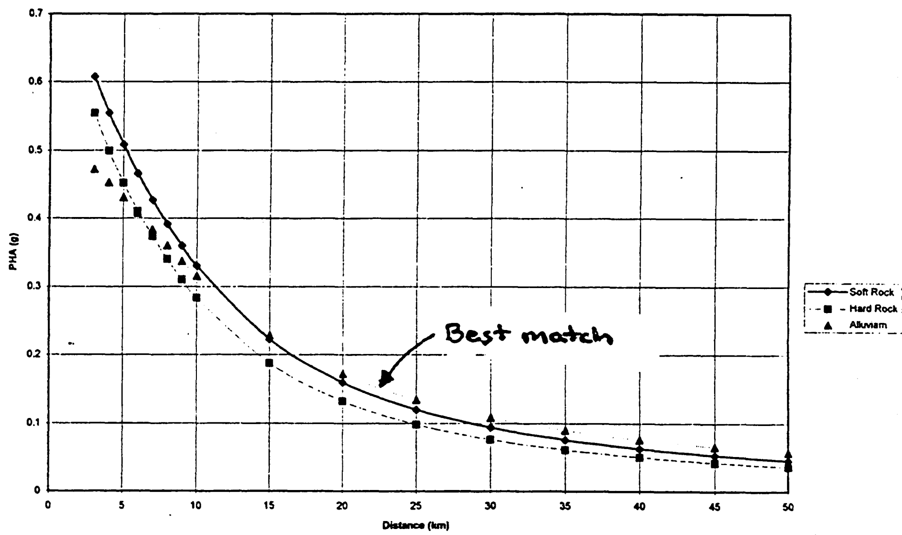
3.8 Determine and plot the variations of peak horizontal acceleration with distance for a $M_w = 6.5$ earthquake at soft rock, hard rock, and alluvium sites using the attenuation relationship of Campbell and Bozorgnia (1994). Which of these conditions agrees best with the attenuation relationship of Campbell (1981)?

Campbell (1981)



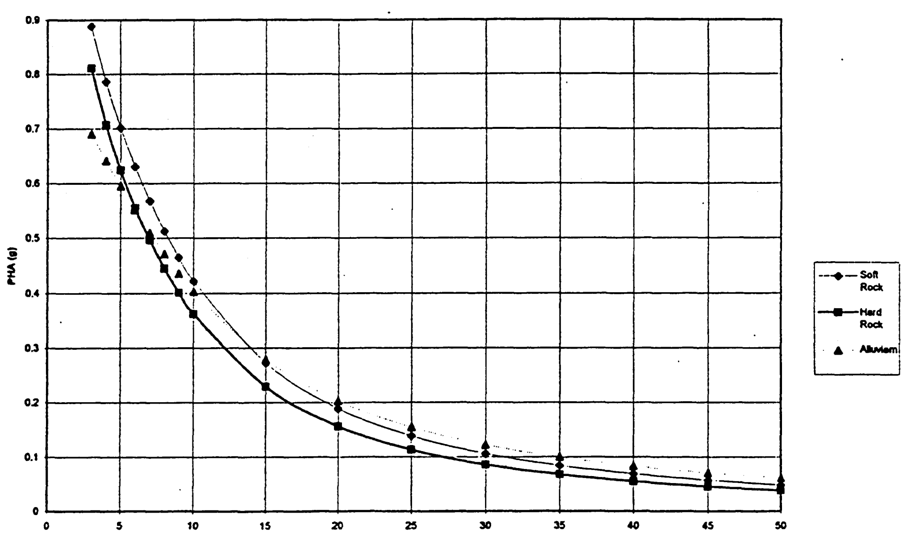
Campbell & Bozorgnia (1994)

Normal Faulting (F=0)



Campbell & Bozorgnia (1994)

Reverse Faulting (F=1)



3.9 Using the attenuation relationship of Toro et al. (1994), determine the probability that a $M_w = 7$ earthquake in mid-continental eastern North America would produce a peak acceleration greater than 0.30 g at a point located 50 km from the closest point of rupture.

Attenuation relationship:

$$\ln PHA = 2.20 + 0.81(M_w - 6) - 1.27 \ln R_m + 0.11 \max\left[\ln \frac{R_m}{100},\ 0\right] - 0.0021 R_m$$

where $R_m = \sqrt{R^2 + 9.3^2}$

For $M_w = 7$ and $R = 50$ km

$R_m = 50.9$ km

$\ln PHA = 0.124g$

$$\left.\begin{array}{l} \sigma_m = 0.36 + 0.07(M_w - 6) = 0.43 \\ \sigma_R = 0.20 \end{array}\right\} \sigma_{\ln PHA} = \sqrt{\sigma_m^2 + \sigma_R^2} = 0.474$$

Assuming residuals are lognormally distributed

$$z = \frac{\ln(0.30) - \ln(0.124)}{0.474} = 1.864$$

From Table C-1

$F_z(1.864) = 0.969$

Then

$$P[PHA > 0.30g] = P[z > 1.864] = 1 - F_z(1.864) = 0.031 = 3.1\%$$

3.10 Determine the peak horizontal velocity that would have a 10% probability of being exceeded by a $M_w = 7.5$ earthquake occurring at a distance of 40 km. Use the Joyner and Boore (1988) attenuation relationship.

From Joyner & Boore (1988) random component

$$\log PHV = 2.09 + 0.49(M-6) - \log R - 0.0026R + 0.17 \qquad \sigma_{\log PHV} = 0.33$$

$$\text{where} \quad R = \sqrt{r_0^2 + (4.0)^2}$$

For $r_0 = 40$ km and $M = 7.5$, $R = 40.2$ km and

$$\overline{\log PHV} = 1.286 \implies PHV = 19.3 \text{ cm/sec}$$

PHV with 10% probability of being exceeded corresponds to

$$F_Z(z) = 0.90$$

From Table C-1, the corresponding value of z is

$$z = 1.283 = \frac{\log PHV - \overline{\log PHV}}{\sigma_{\log PHV}}$$

Substituting $\overline{\log PHV} = 1.286$ and $\sigma_{\log PHV} = 0.33$

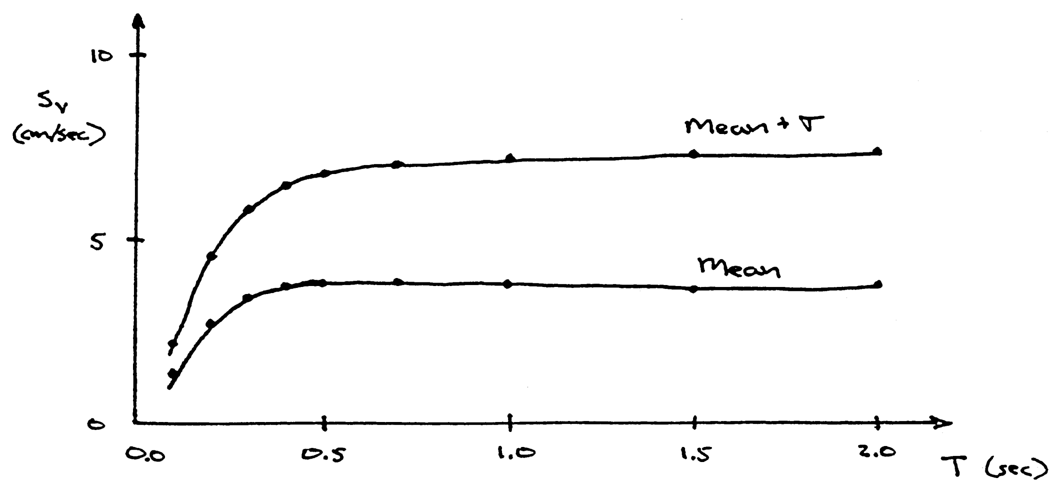
$$\log PHV = (1.283)(0.33) + 1.286 = 1.709$$

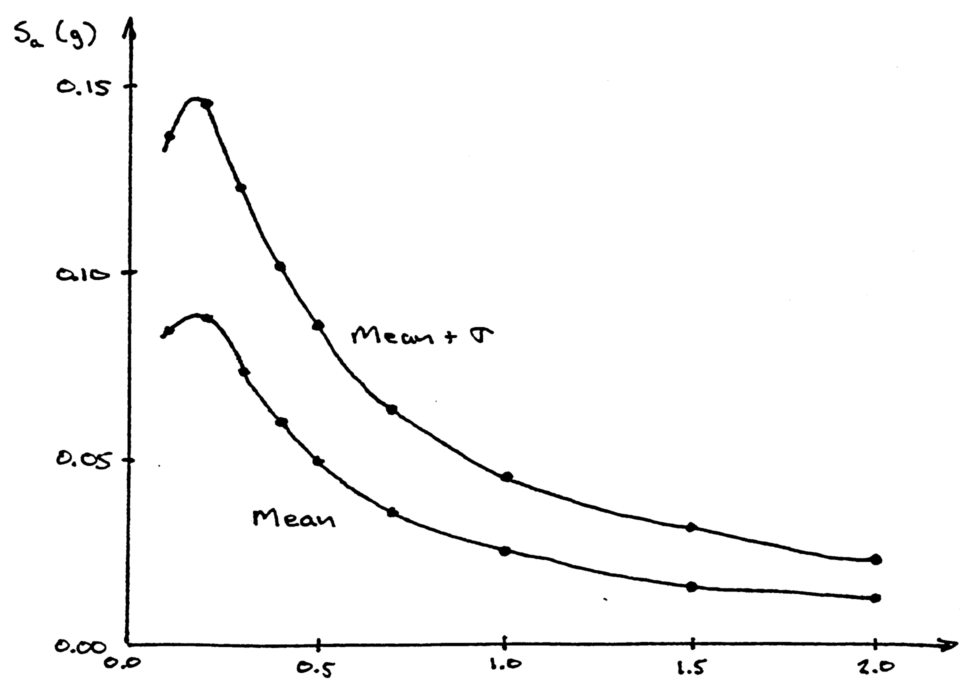
Then,

$$PHV = 10^{1.709} = 51.2 \text{ cm/sec}$$

3.11 Using the Boore et al. (1994) attenuation relationship, determine and plot the mean and mean ± one standard deviation response spectra for a $M_w = 6.75$ earthquake that occurs at a distance of 70 km.

		Mean			Mean + σ	
T (sec)	log S_v	S_v (cm/sec)	S_a (g)	log $S_v + \sigma_{\log S_v}$	S_v	S_a
0.1	0.120	1.32	0.085	0.328	2.13	0.137
0.2	0.443	2.78	0.089	0.658	4.55	0.146
0.3	0.538	3.45	0.074	0.764	5.80	0.123
0.4	0.572	3.73	0.060	0.808	6.43	0.103
0.5	0.586	3.86	0.050	0.830	6.76	0.087
0.7	0.588	3.88	0.036	0.845	7.00	0.064
1.0	0.581	3.81	0.025	0.851	7.10	0.046
1.5	0.570	3.71	0.016	0.855	7.16	0.031
2.0	0.571	3.73	0.012	0.864	7.32	0.023





3.12 Determine the values of Arias intensity that have 10%, 25%, 50%, 75%, and 90% probabilities of being exceeded by a $M_w = 7.25$ earthquake at a distance of 45 km. Use the attenuation relationship of Wilson (1993) with zero anelastic absorption.

From Wilson (1993),

$$\log I_a = M_w - 2\log R - 3.990 + 0.365(1-P)$$

For $M_w = 7.25$ and $R = 45$ km

$$\log I_a = 7.25 - 2\log 45 - 3.990 + 0.365(1-P)$$

$$= -0.0464 + 0.365(1-P)$$

Then

P	$\log I_a$	I_a (m/sec)
0.10	0.282	1.91
0.25	0.227	1.69
0.50	0.136	1.37
0.75	0.045	1.11
0.90	-0.010	0.98