Suspensions II computation book   1985 March 13 - 1985 March 19

COMPUTATION BOOK

NAME

Course Suspensions II 20F-001

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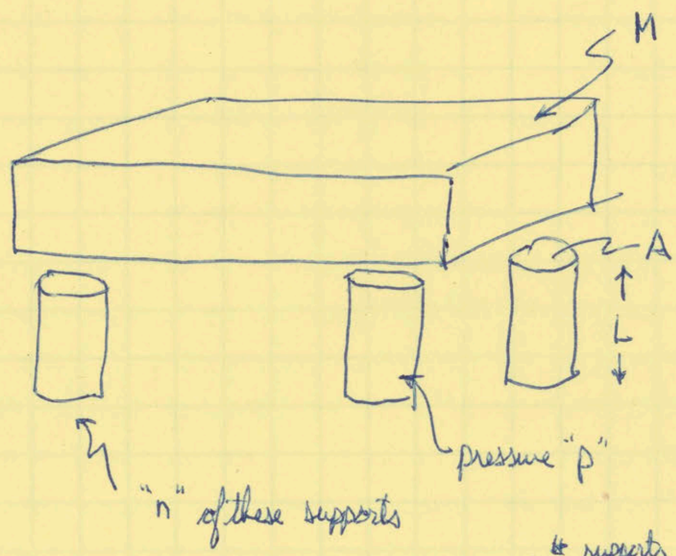
Resonant frequency of an Air suspension:



to hold up the table: $\underbrace{p \cdot A}_{\text{force/support}} \cdot \overset{\#\text{ supports}}{n} = Mg$ vertical force balance

in the supports: $pV = NkT$ ideal gas law

$$\underbrace{p \cdot A}_{\downarrow} \cdot L = NkT$$

$$F = \frac{NkT}{L}$$ ideal spring law $F = -k_{spring} x$

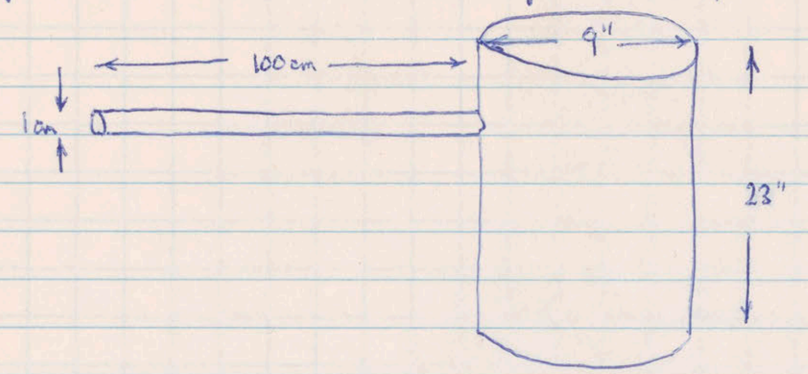
$$\frac{\partial F}{\partial x} = \underbrace{-\frac{NkT}{L^2}}_{-k_{spring}}$$ but $NkT = L \cdot pA = L \cdot \frac{Mg}{n}$

$$= -\frac{Mg}{nL}$$

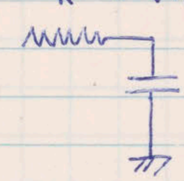
$$\boxed{\omega_0 = \sqrt{\frac{k_{spring}}{M}} = \sqrt{g/nL}}$$

3/13/85 – from Lansing catalog, get $\omega_0 = \sqrt{\frac{g\gamma}{nL}}$ where $\gamma = C_p/C_v = 1.4$ for air with pV^γ = constant law instead of $PV = nkT$

Approximate Table Air Suspension Response time:



$\Rightarrow$



$$\therefore \ f_c = \frac{1}{2\pi RC} = \frac{1}{2\pi}\left(\frac{F}{V}\right)$$

$$V = \pi\left(\frac{9}{2}\right)^2 (23)\left(\frac{2.54\,\text{cm}}{1''}\right)^3 = 2.4\times10^4\ \text{cm}^3$$

for a tube:

$$F = \frac{\pi a^4 P_a}{8\eta l} \quad \text{in the viscous limit (p 82 Dushman)}$$

$a = .5\,\text{cm}$

$l = 100\,\text{cm}$

$P_a = (100\,\text{psi})\left(6.9\times10^4\,\frac{\text{dyne/cm}^2}{\text{psi}}\right) = 6.9\times10^6\ \text{dyne/cm}^2$

$\eta = 178.2\times10^{-6}\ \text{gm/cm-sec for } N_2$

$$F = \frac{\pi(.5)^4(6.9\times10^6)}{8(178\times10^{-6})(100)} = 9.5\times10^6\ \text{cm}^3/\text{sec}$$

$$f_c = \frac{1}{2\pi}\frac{F}{V} = \frac{1}{2\pi}\frac{9.5\times10^6}{2.4\times10^4} = \boxed{63\,\text{Hz}}$$

upper limit because:

a.) $P_a \le 100\,\text{psi}$

b.) $l \ge 100\,\text{cm}$

c.) orifices neglected.

d.) $\eta_{AR}/\eta_{N_2} = 1.22$

$\Rightarrow$ <u>very</u> sensitive to tubing diameter

2/14/85

Quick check of feedthrough for the 2271A mounted in loudspeaker driver:

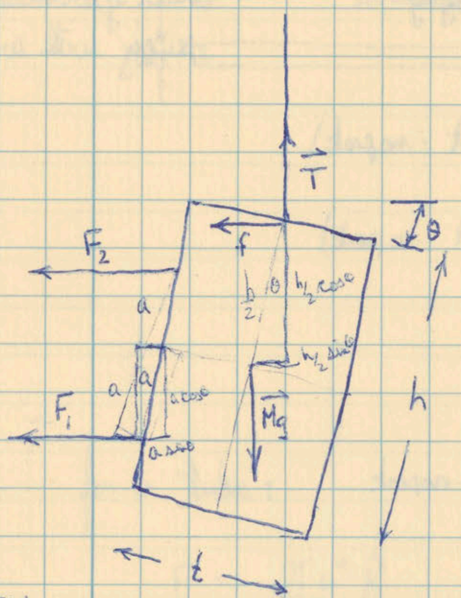
f (Hz)	amplitude with speaker connected	amplitude with speaker hanging	driver grounded to power supply with wire
2060Hz	−92.0 (−130 ambient)	ambient	
	−77.4	−129.3 (ambient - no peak)	
206Hz	−80.5	−131.3 (ambient - no peak)	

Compare with 7707

206	−49.4	−110 ambient - no peak
2060	−50.6	−111.3

3/1/85

Electrostatic forces to torque a free mass



$$\Sigma T = T \cdot \frac{h}{2}\sin\theta - F_1 a\cos\theta + F_2 a\cos\theta + f\frac{h}{2}\cos\theta = 0$$

for a string, $f \approx 0$, $T = Mg$

$$\Rightarrow (F_1 - F_2) = \frac{Th}{2a}\tan\theta - \cancel{\frac{fh}{2a}}$$

for a capacitor plate, $F = \frac{1}{8\pi}\frac{V^2}{x^2}A$

for an EM:

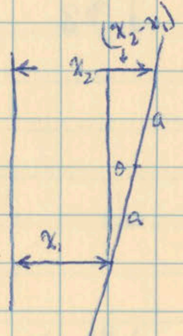
$h = 24.2$

$t = 8.8$

$w = 14$

$a = \sim 6$ $\quad \sim 7$

θ_y $\quad \theta_x$



$$\boxed{\frac{x_2 - x_1}{2a} = \sin\theta}$$

so $x_2 = x_1 + 2a\sin\theta$

$$\frac{x_2}{x_1} = 1 + \frac{2a}{x_1}\sin\theta$$

$$F_1 - F_2 = \frac{A}{8\pi}\left[\left(\frac{V_1}{x_1}\right)^2 - \left(\frac{V_2}{x_2}\right)^2\right] = \frac{Th}{2a}\tan\theta$$

$$V_1^2 = \frac{8\pi}{A}\left[\frac{Th}{2a}\tan\theta\right]x_1^2 + V_2^2\left(\frac{1}{1 + \frac{2a\sin\theta}{x_1}}\right)^2$$

$\Rightarrow$ let $M = 2.7 \times (24.2 \times 8.8 \times 16) = 9200$ gms

$g = 980$ cm/sec^2

$\Rightarrow T = Mg = 9{,}016{,}000$ dynes

$x_1 = .9$ mm $= .09$ cm

$\theta = 10^\circ$

$A = 50$ cm^2

$V_2 = \frac{400}{300} = 1.3$ statvolts

$$V_1^2 = \left(\frac{8\pi}{50\,\text{cm}^2}\right)\left(\frac{9.016\times10^6}{2(6)}\tan 10^\circ\right)(.09)^2 + (1.3)^2\left(\frac{1}{1 + \frac{2(6)\sin\theta}{.09}}\right)^2$$

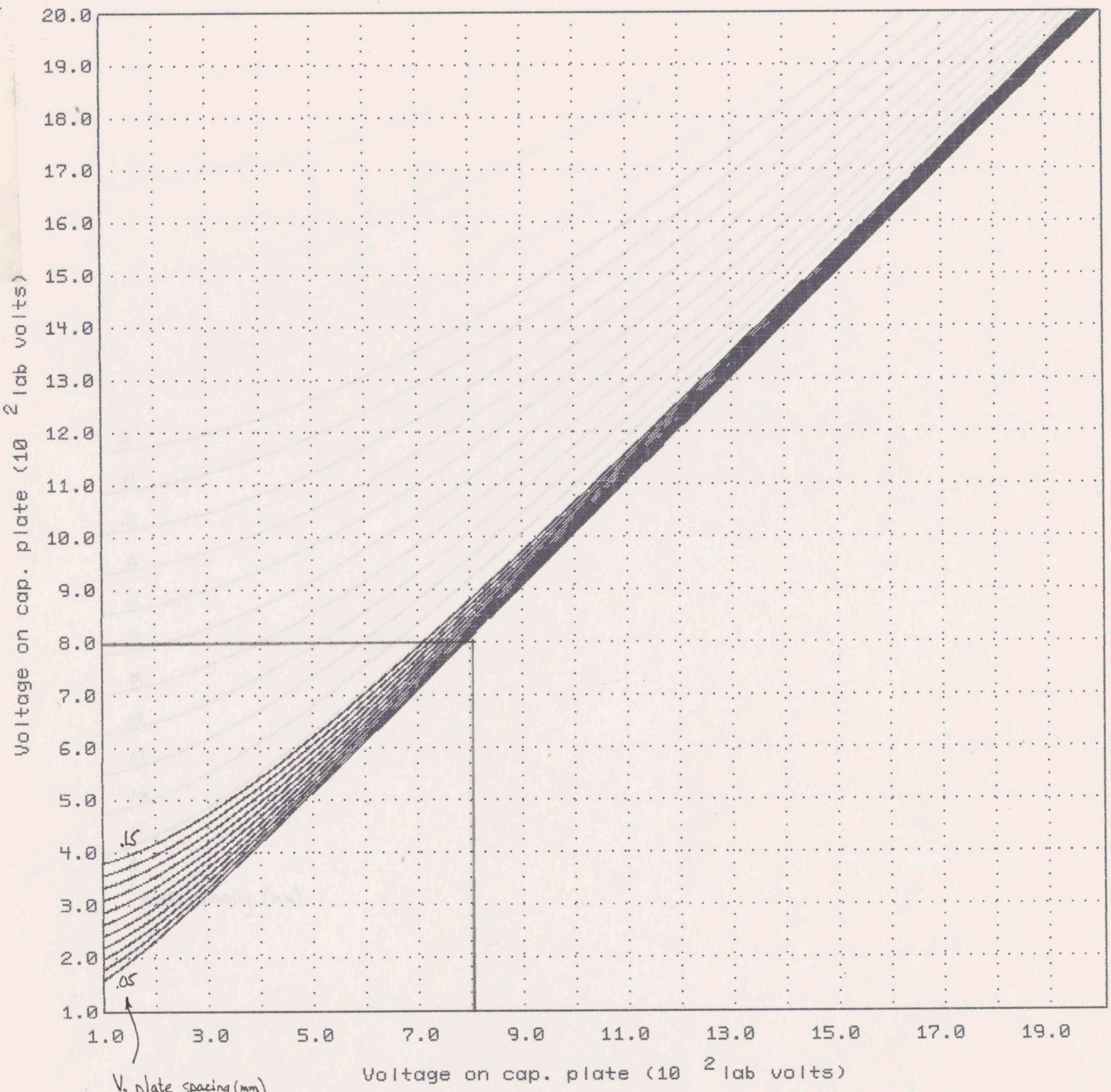
$V_1^2 = 53.5$ (statvolt)^2 $= 2.2$ kV!

$x_2 = 1.1$ mm

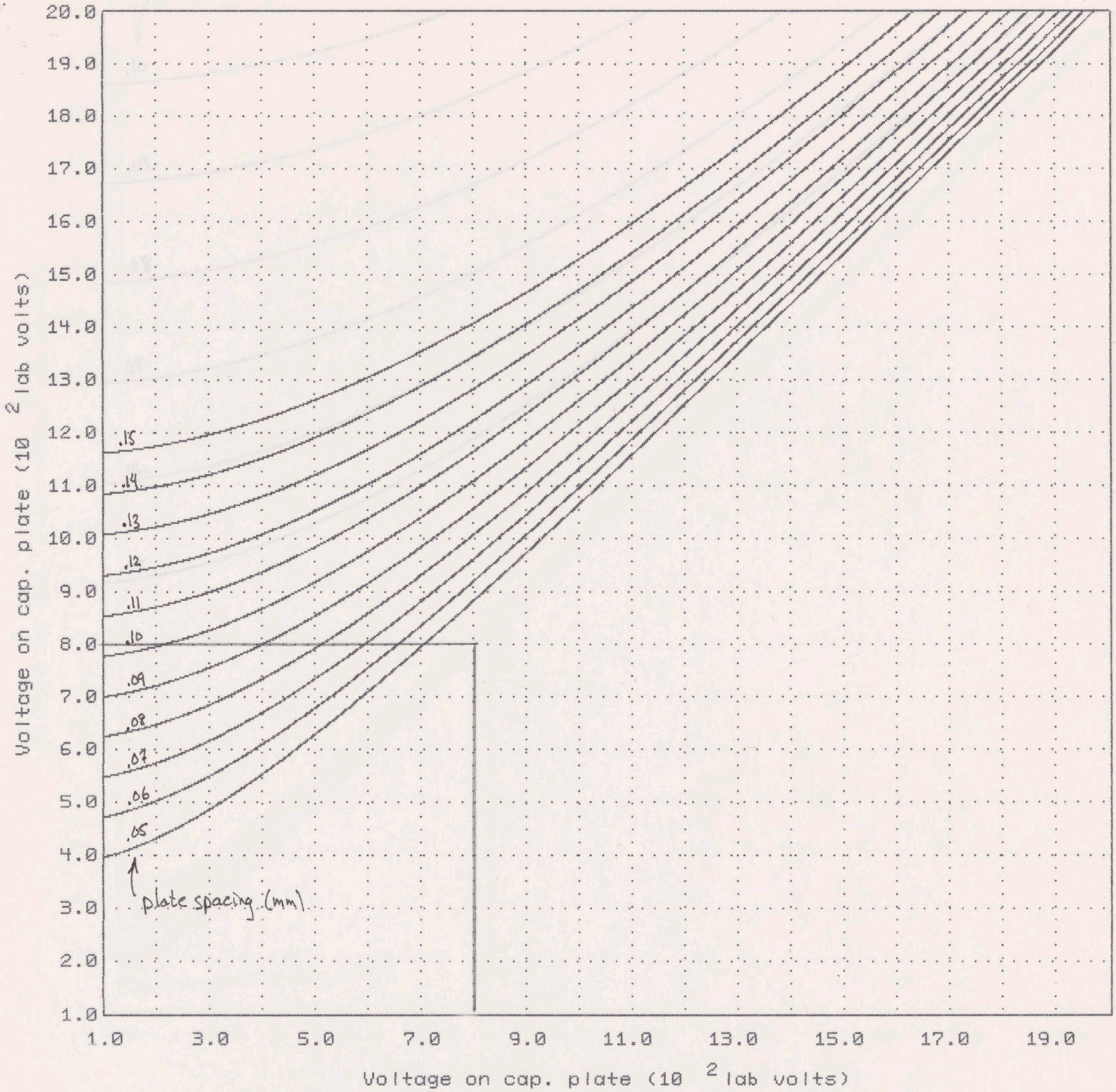
Alternatively,

$$V_1^2 = (x_2 - 2a\sin\theta)^2\left[\frac{8\pi Mgh}{2Aa}\tan\theta + \left(\frac{V_2}{x_2}\right)^2\right]$$

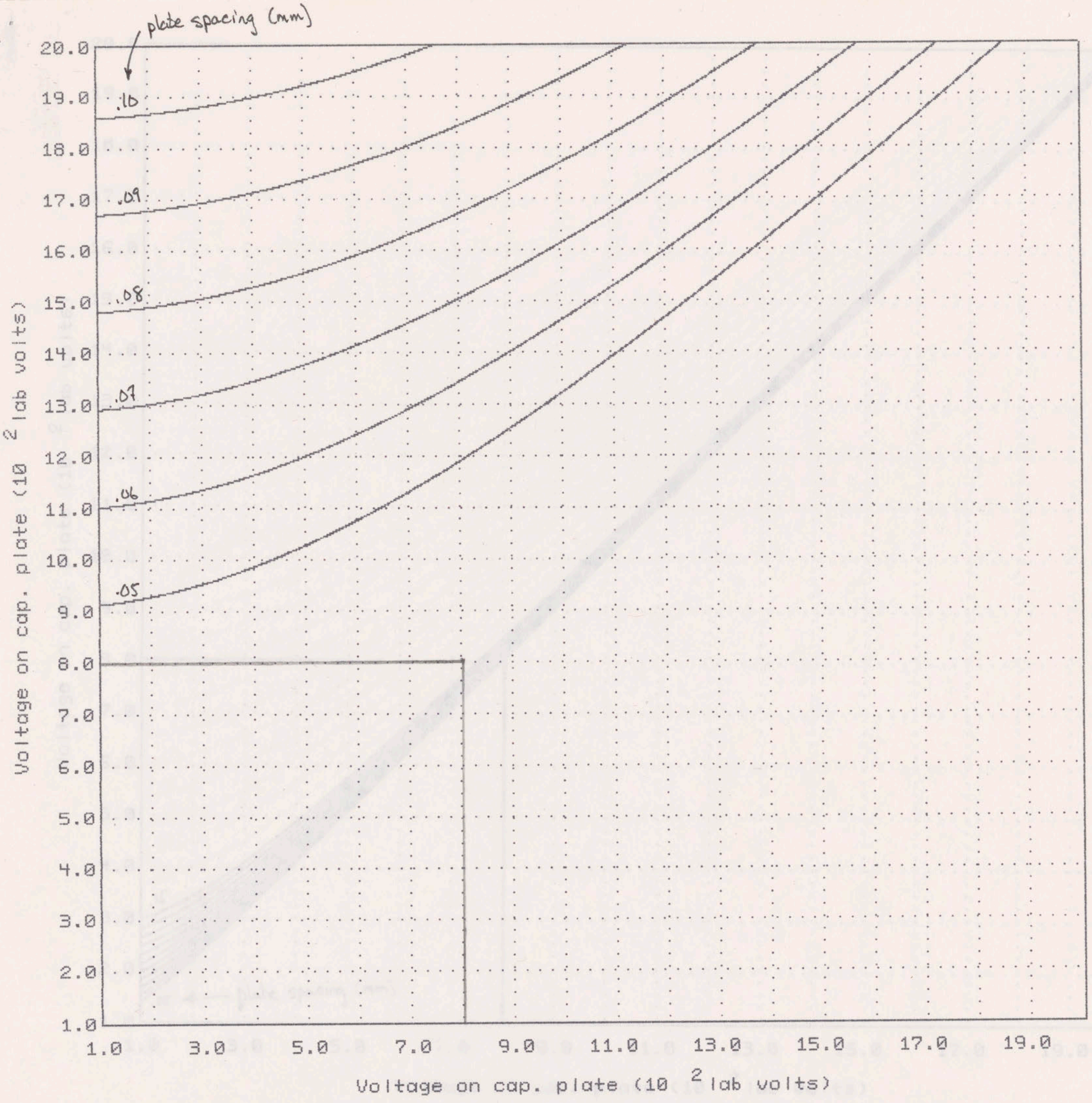
$\Rightarrow$ given θ, plot V_1 vs. V_2 for various x_2



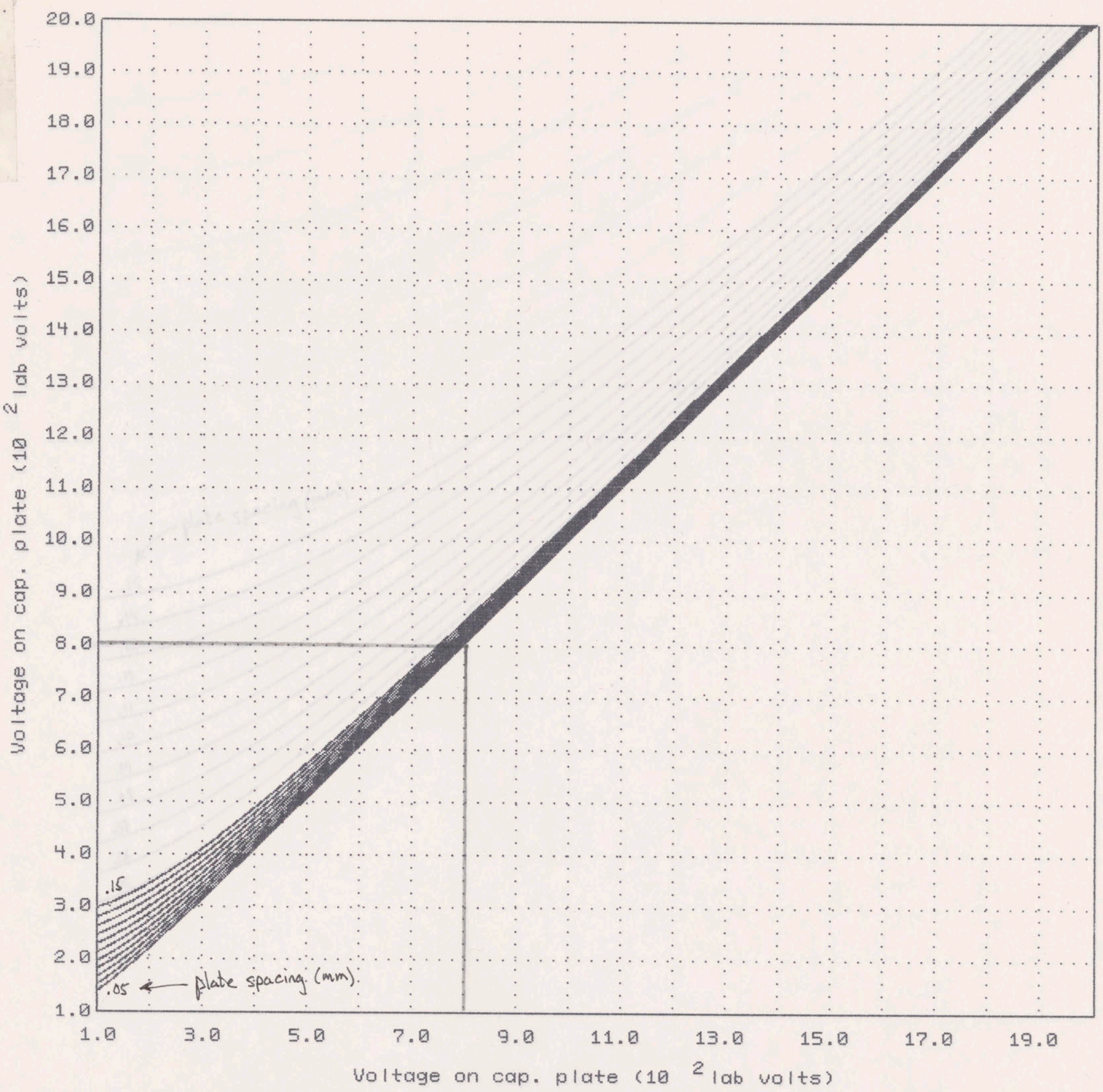
Capacitor plate voltages necessary to twist an end mass
by 1.0 arc seconds
in the theta-x direction



Capacitor plate voltages necessary to twist an end mass
by 10. arc seconds
in the theta-x direction

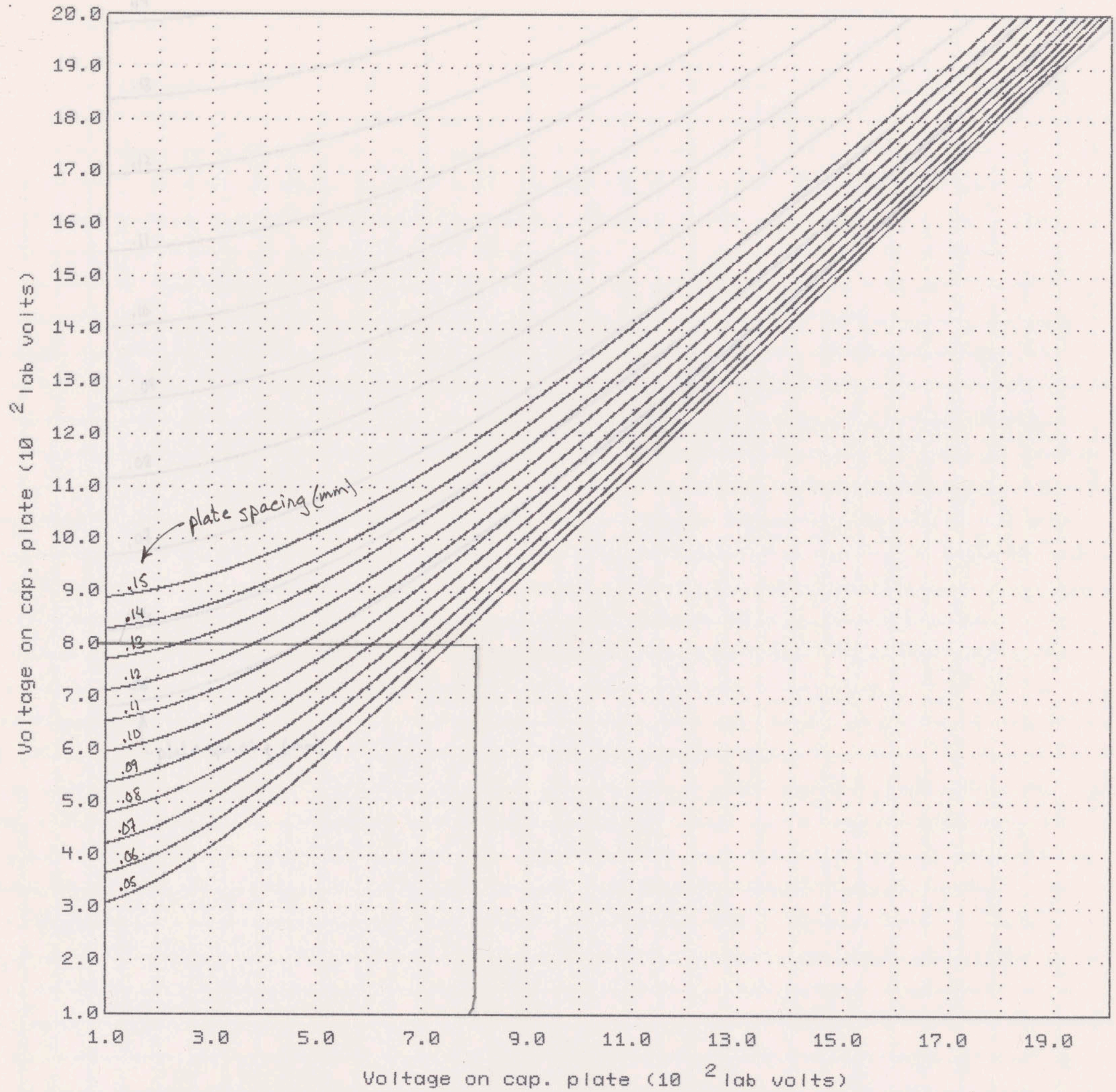


Capacitor plate voltages necessary to twist an end mass
by 60. arc seconds
in the theta-x direction



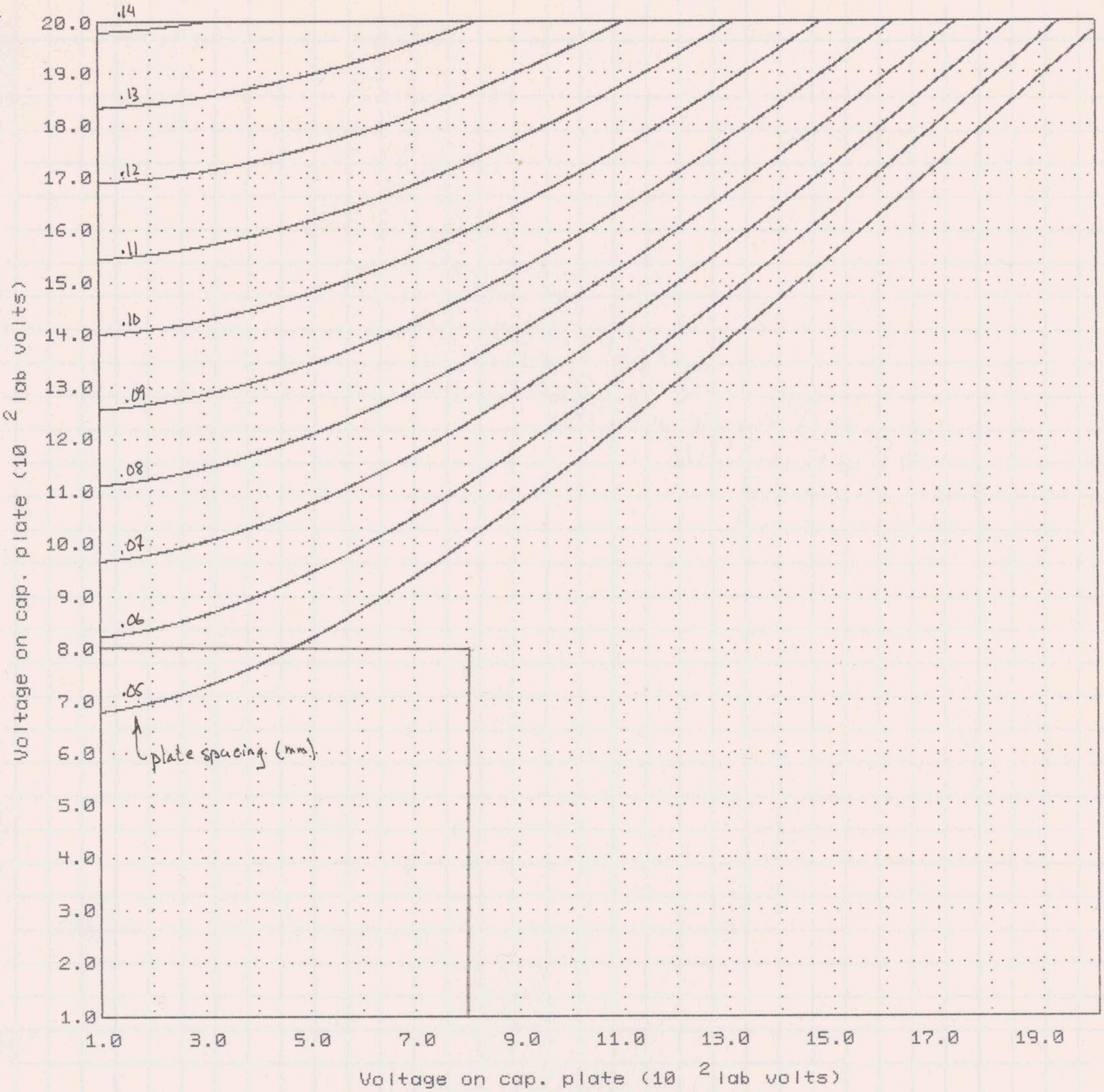
Capacitor plate voltages necessary to twist an end mass
by ~~4.85E-06~~ arc seconds
in the theta-y direction

1 asec

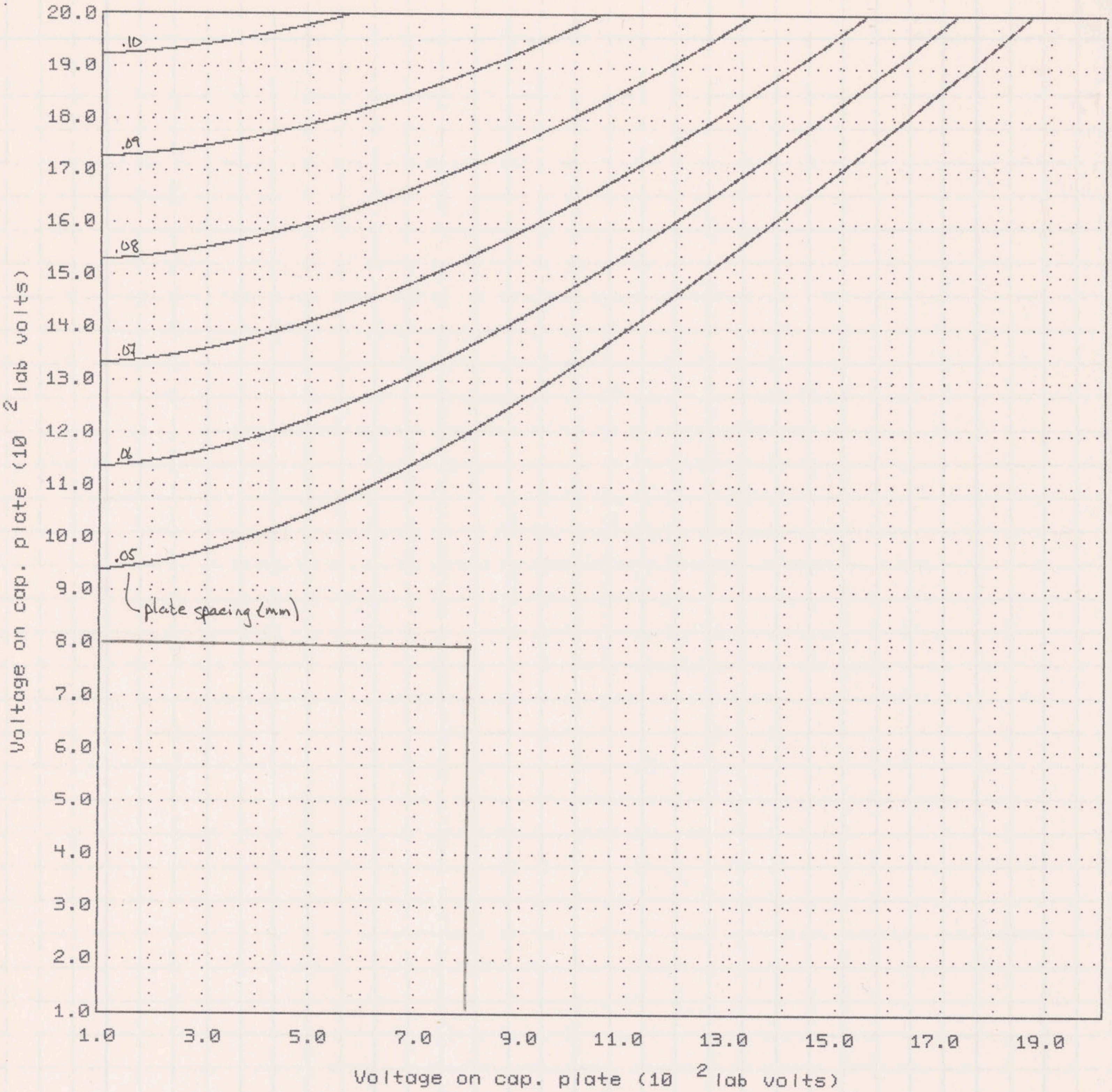


Capacitor plate voltages necessary to twist an end mass
by ~~4.85E-05~~ arc seconds
in the theta-y direction

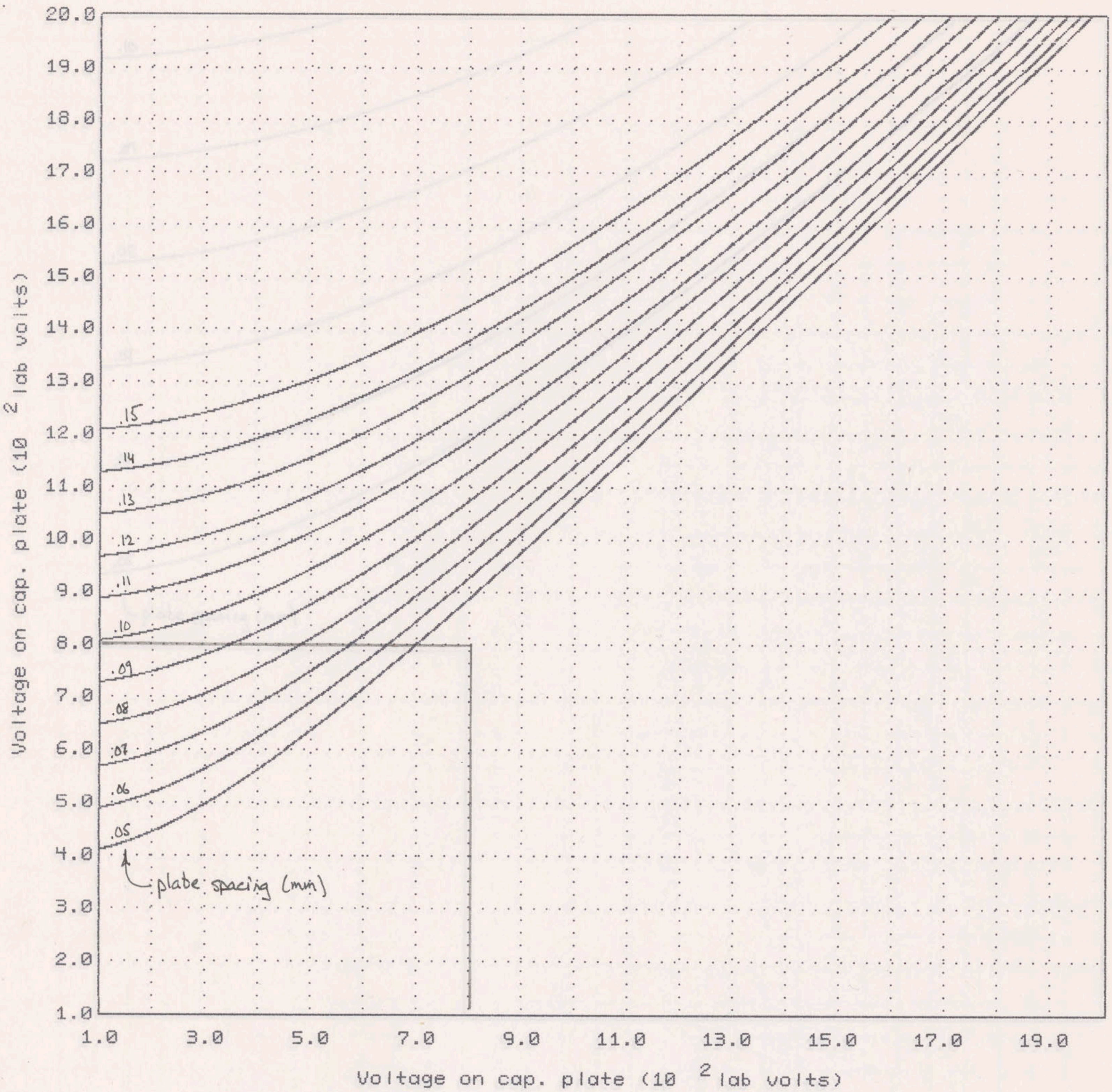
10 sec



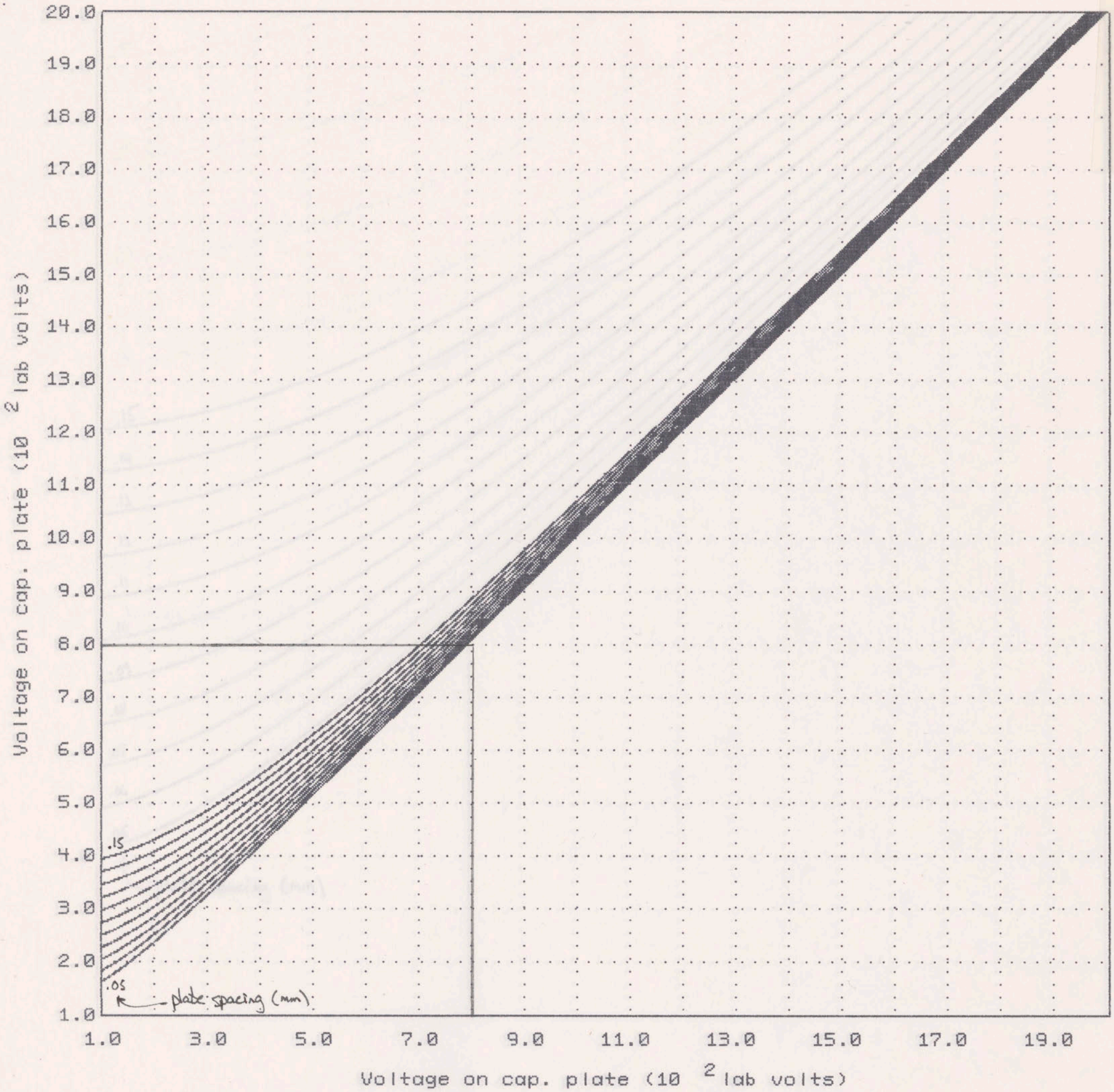
Capacitor plate voltages necessary to twist an end mass
by 2.91E-04 arc seconds
in the theta-y direction



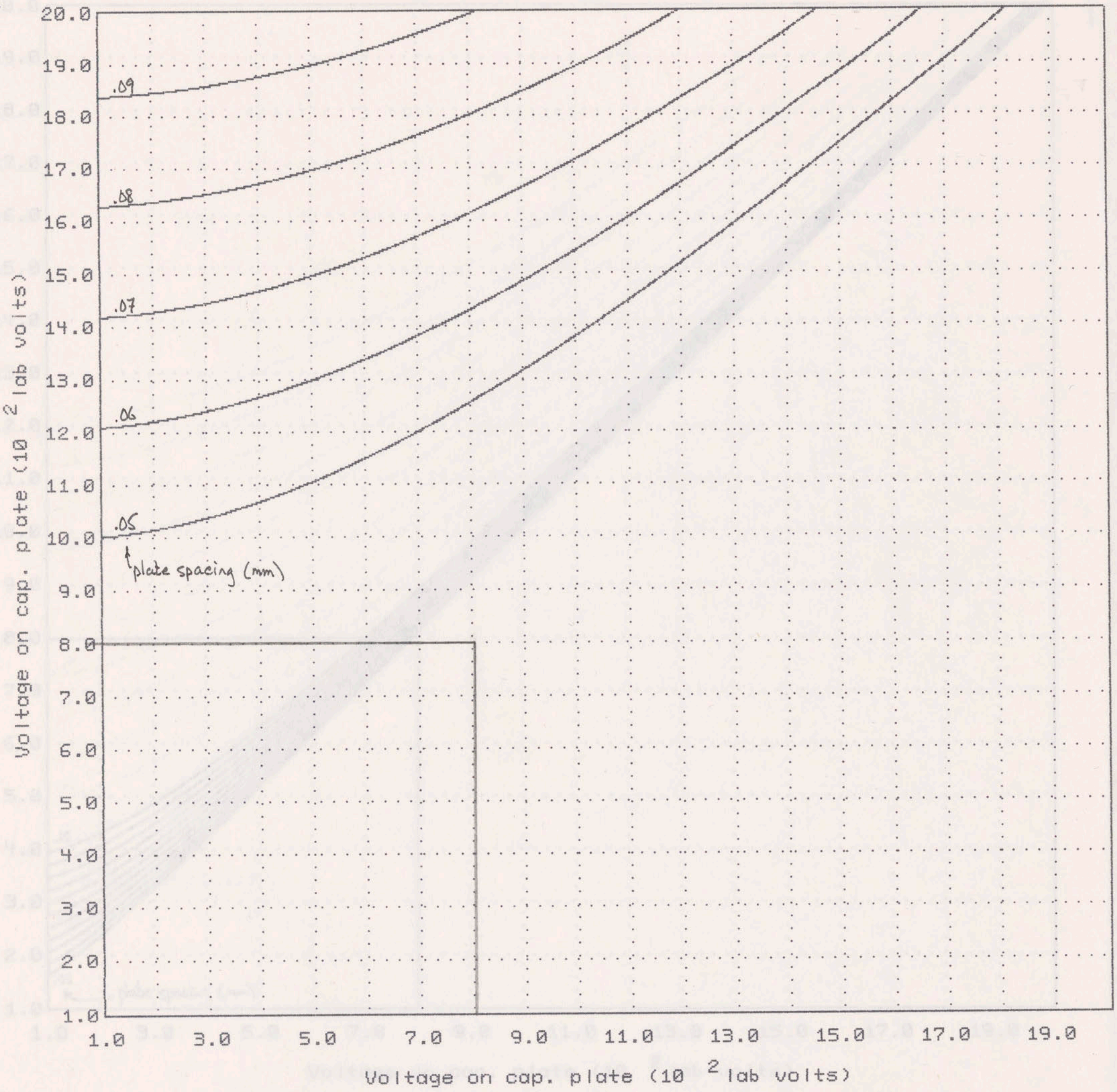
Capacitor plate voltages necessary to twist the central mass
by 60. arc seconds
in the theta-x direction



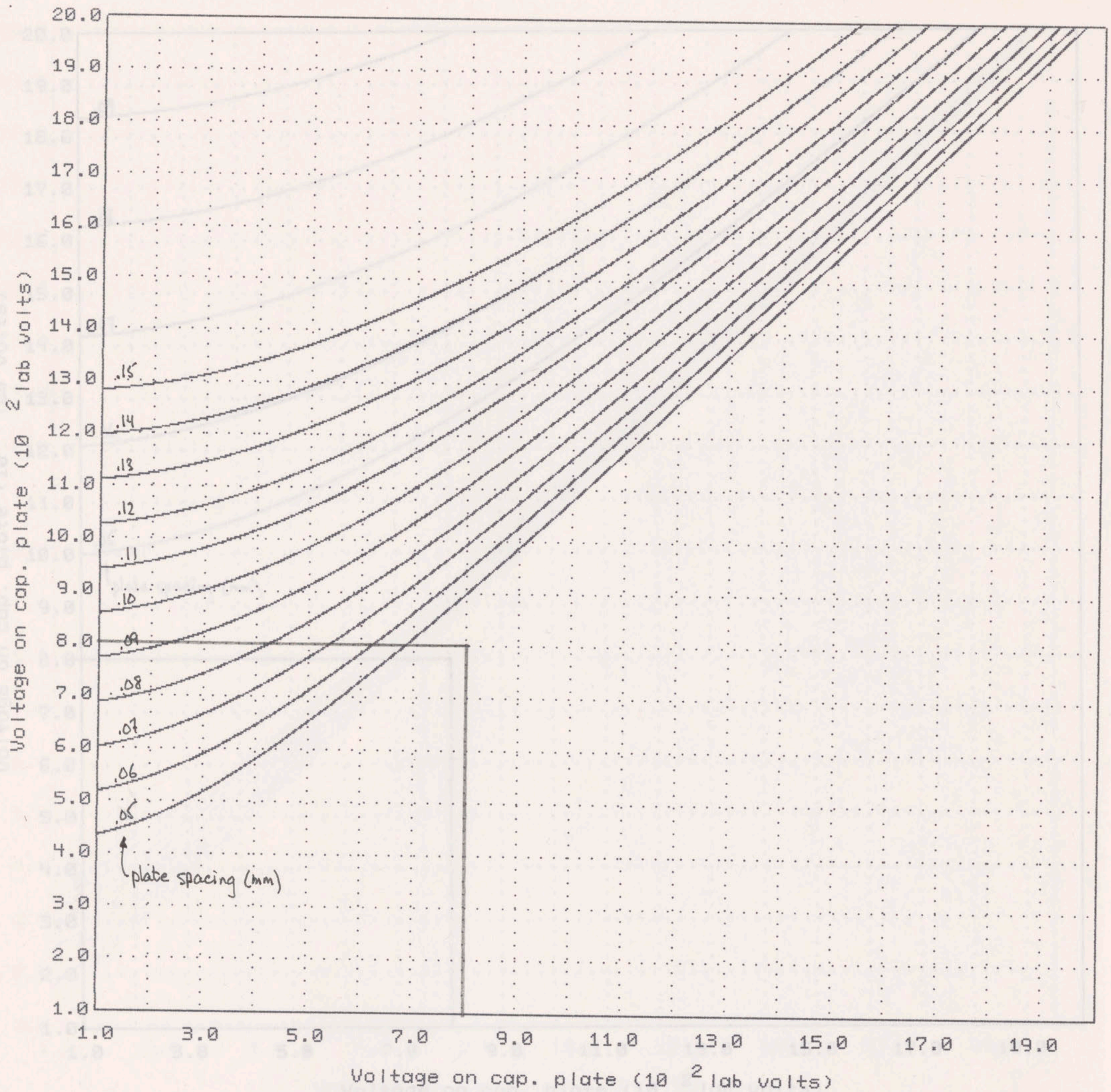
Capacitor plate voltages necessary to twist the central mass
by 10. arc seconds
in the theta-x direction



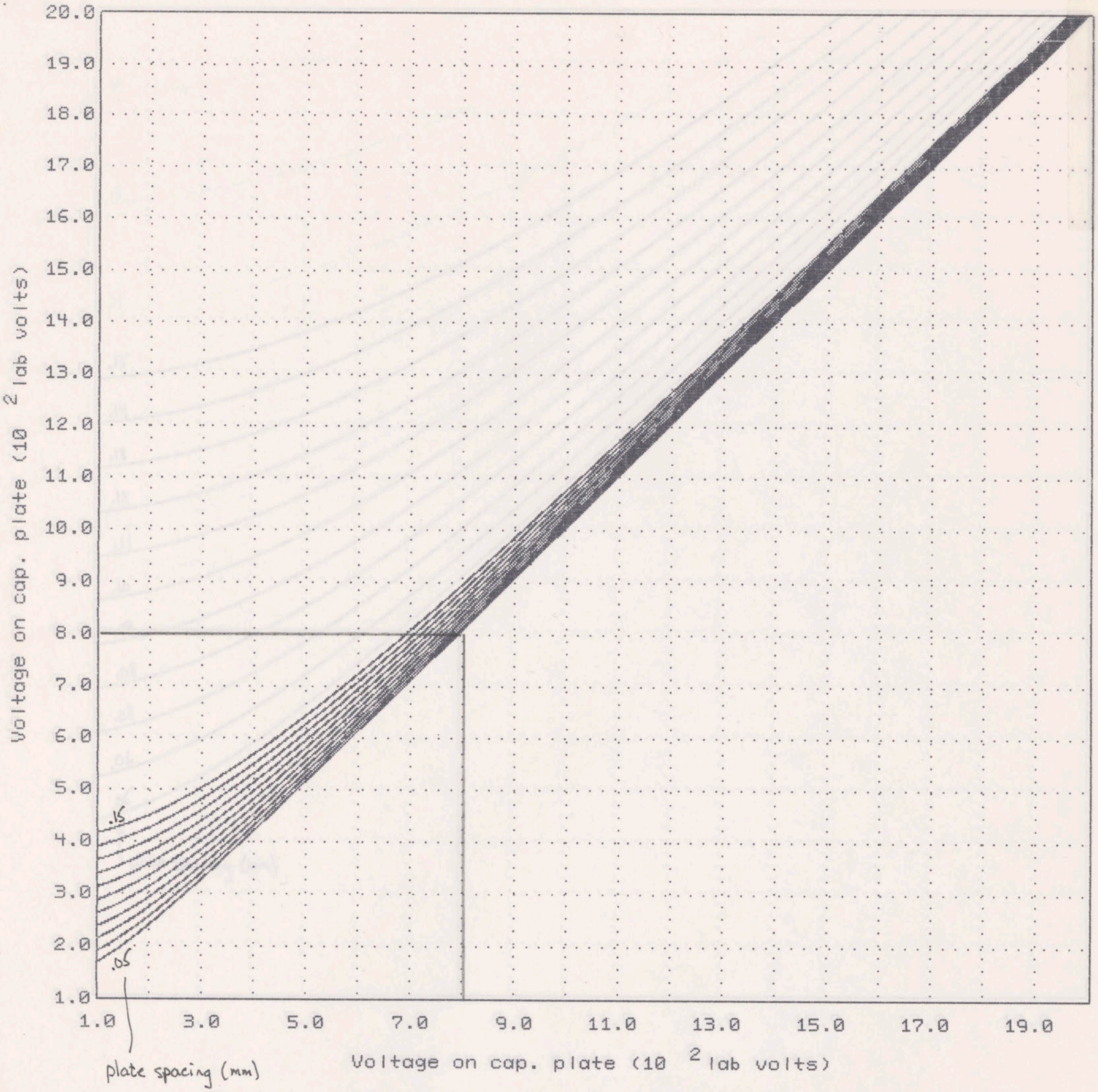
Capacitor plate voltages necessary to twist the central mass
by 1.0 arc seconds
in the theta-x direction



Capacitor plate voltages necessary to twist the central mass
by 60. arc seconds
in the theta-y direction



Capacitor plate voltages necessary to twist the central mass by 10. arc seconds in the theta-y direction



Capacitor plate voltages necessary to twist the central mass
by 1.0 arc seconds
in the theta-y direction

Torsion for a rod:

$$T = \frac{\mu \pi r^4}{2L} \phi \Rightarrow k_{torsion} = \frac{\mu \pi r^4}{2L}$$

where $\mu = \frac{Y}{2(1+\sigma)} \approx \frac{3}{8} Y$

$L = 120$ cm

torsional frequency: $I \ddot{\phi} = -k_{tors} \phi$

$$\omega_0^2 = \frac{k_{tor}}{I_z}$$

$I_{z,em} = 1.85 \times 10^5$ gm·cm^2

$I_{z,cm} = 8.00 \times 10^5$ gm·cm^2

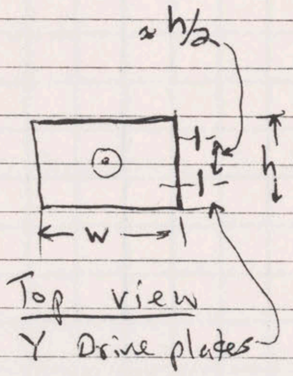
rod	μ	k_{tors}	$\frac{1}{2\pi}\sqrt{k_{tor}/I_z}$ EM	$\frac{1}{2\pi}\sqrt{k_{tor}/I_z}$ CM
1/4" Al	2.66×10^{11}	5.66×10^8	8.8 Hz	4.23 Hz
.020" SS	7.69×10^{11}	6.70×10^4	.10 Hz	.046 Hz
.010" W	1.28×10^{12}	6.97×10^3	.031 Hz	.015 Hz (67 sec)

Ability to twist the mass with Electrostatic Plates

$$I\ddot{\theta} = k\,\theta \quad \text{where} \quad k = \frac{\text{Torque}}{\theta}$$

and $\omega_{tor} = \sqrt{\dfrac{k}{I}}$

For the masses $I = \dfrac{M}{12}(w^2+h^2)$:



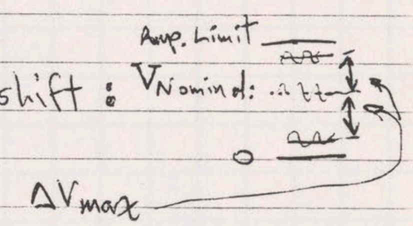
Thus

$$k = \omega_{tor}^2 \frac{M}{12}(w^2+h^2)$$

If α is the cgs force/lab volt constant for one plate then :

$$\text{Max torque} = 2 \cdot \frac{h}{4} \cdot \alpha\, \Delta V_{max}$$

where ΔV_{max} is the maximum DC bias shift :



So the maximum twist (in radians) is :

$$\theta_{DC\,MAX} = \frac{\text{Max torque}}{k} = \frac{\frac{h}{2}\,\alpha\,\Delta V_{max}}{\omega_{tor}^2 \frac{M}{12}(w^2+h^2)}$$

$$\boxed{\theta_{DC\,MAX} = \frac{\frac{1}{2h}\,\alpha\,\Delta V_{max}}{\omega_{tor}^2 \frac{M}{12}\left(1+\left(\frac{w}{h}\right)^2\right)}}$$

For the end mass Y systems

$h \approx 8.5$ cm
$\alpha \approx 1.35$ cgs force/lab volt
$\Delta V_{max} \approx (+/-)\,200V$
$M \approx 8000g$
$w/h \approx 1.65$
$V_{nom} \approx 450V$

$$\theta_{DC\,MAX} = \frac{0.0064}{\omega_{tor}^2} \text{ radians}$$

Now $\omega_{tor} \approx (2\,Hz \Rightarrow)\ 15$ rad/sec
gives $\theta_{DC\,MAX} \approx 28 \times 10^{-6}$ rad
(= 6 arcseconds)

$1\,\widehat{sec} = 4.8 \times 10^{-6}$ rad
$\approx 5\,\mu rad$

If $\left\{ \begin{array}{l} \omega_{tor} \approx 1/60 \text{ sec} \quad \left(f_{tor} = \frac{1}{377\text{ sec}}\right) \\ \theta_{DC\,MAX} = 23 \text{ radians} \approx 3.7 \text{ twists} \end{array} \right.$

$\left\{ \begin{array}{l} \omega_{tor} \approx 1/9.5 \text{ sec} \quad \left(f_{tor} = \frac{1}{60\text{ sec}}\right) \\ \theta_{DC\,MAX} \approx 0.5 \text{ radian} \approx 0.1 \text{ twists} \end{array} \right.$

crucial difference in a factor of 6 in ω_{tor}.

March 9, 1985

Compliance of Bellows:

March 11, 1985

Characterizing the XYZθ movers:

Drive along the x direction with loudspeaker on shelf:

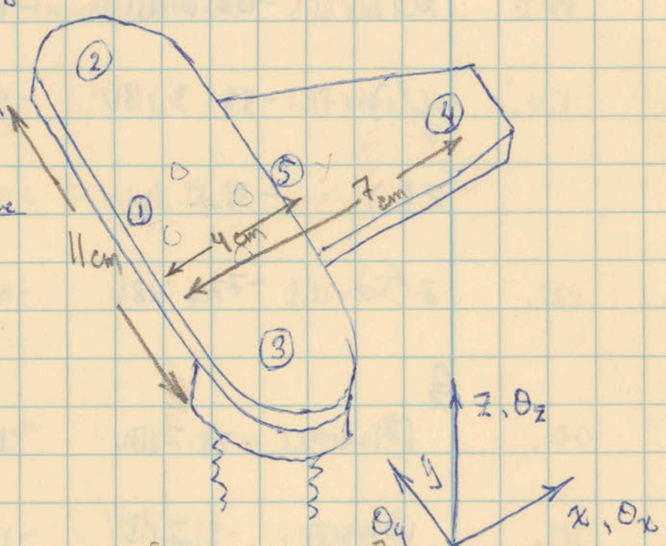
$f = 47.2$ Hz. , Current monitor -22.8 dBV/$\sqrt{Hz}$

Sniff around with accelerometer - verify that motion is only x translation to 10% level

x drive: -22.8 dBV/$\sqrt{Hz}$ = i $\qquad m = F/a \approx 500$ kg

BW = 2.90 Hz $\qquad i = -18.1$ dBV $\Rightarrow F = 4.3 \times 10^{4}$ dynes

2271 accel = -100.3 dBV $\Rightarrow a = 8.6 \times 10^{-2}$ cm/sec^2 $\Rightarrow 9.78 \times 10^{-7}$ cm



Response

Position	7707 amp	ϕ	motion (cm)	response/drive
x (1)	-55.6 dBV ~~-60.1 dBV/$\sqrt{Hz}$~~	$-14°$	2.27×10^{-6}	2.32
y (1)	-77.1 dBV	$-29°$	1.91×10^{-7}	.195
z (1)	sometimes up to -85 dBV, w/ -95 dBV dips(?) -89.0 dBV	$+140°$	4.86×10^{-8}	.0497
z (5)	amplitude is roughly steady -73.5 dBV	phase very sensitive to location of accel. $-186°$	2.30×10^{-7}	
θ_x (2) vert	-77.7 dBV	$-176°$	2.89×10^{-7}	.296
(3) vert	-85.3 dBV	$-169°$	7.44×10^{-8}	7.6×10^{-2} .076
θ_y (1) vert				
(4) vert	-69.7 dBV	$+172°$	4.48×10^{-7}	.458
θ_z (2) horiz	-54.6 dBV	$-13°$	2.55×10^{-6}	2.61
(3) horiz	~~-64.0~~ -55.4 dBV	$-14°$	2.32×10^{-6}	2.38

$$\theta_x = \left[\frac{2.89 \times 10^{-7} - 7.44 \times 10^{-8}}{2(11)}\right] = 9.8 \times 10^{-9}$$

$$-\theta_y = \frac{1}{2}\left(\frac{4.48 \times 10^{-7} - 4.86 \times 10^{-8}}{7}\right) = 2.85 \times 10^{-8}$$

$$-\theta_z = \left[\frac{2.55 \times 10^{-6} - 2.32 \times 10^{-6}}{2(11)}\right] = 1.0 \times 10^{-8}$$

z (1)	-86.0 dBV	$68°$	6.86×10^{-8}	.070
z (5)	-75.7 dBV	$-183°$	2.25×10^{-7}	.230

	x	y	z	θ_x	θ_y	θ_z
x	2.3	.20	.05	.01 cm^{-1}	$-$ ~~.06~~ .03 cm^{-1}	$-.01$ cm^{-1}
y						
z						

$$\theta_x = \frac{1}{2}\left[2_{vert} - 3_{vert}\right] \cdot \frac{1}{11\,cm}$$

$$-\theta_y = \frac{1}{2}\left[4_{vert} - 1_{vert}\right] \cdot \frac{1}{7\,cm}$$

$$-\theta_z = \frac{1}{2}\left[2_{horiz} - 3_{horiz}\right] \cdot \frac{1}{11\,cm}$$

11 March 1985

Put two C-clamps on X-stage
(Causes mass to move out of range of Electrostatic Plates)

X drive −18.0 dBV accel: −100.0 dBV
⇒ 4.34×10^{4} ⇒ 1.01×10^{-6} cm

Response

		ϕ	cm	response/drive	
x(1)	−60.0 dBV	−17°	1.37×10^{-6}	1.35	
y(1)	−88.3 dBV	−81°	5.27×10^{-8}	.052	
z(1)	−89.0 dBV	+189°	4.86×10^{-8}	.048	
z(3)	−77.6 dBV	−183°	1.8×10^{-7}	.178	
θ_x					
(2) vert	−78.7 dBV	+174°	1.59×10^{-7}	.157	$\theta_x = \frac{1}{2}\left(\frac{1.59\times10^{-7} - 1.13\times10^{-7}}{11}\right) = 2.1\times10^{-9}$
(3) vert	−81.7 dBV	−177°	1.13×10^{-7}	.111	
θ_y					
(1) vert					
(4) vert	−73.1 dBV	+170°	3.03×10^{-7}	.299	$-\theta_y = \frac{1}{2}\left(\frac{3.03\times10^{-7} - 4.86\times10^{-8}}{7}\right) = 2.12\times10^{-8}$
θ_z					
(2) horiz	−58.2 dBV	+166°	1.68×10^{-6}	1.66	$-\theta_z = 0$
(3) horiz	−58.2 dBV	+166°	1.68×10^{-6}	1.66	

	x	y	z	θ_x	θ_y	θ_z
x	1.35	.05	.05	.002	−.02	0
~~y~~						
~~y~~						
z						

11 March

Move C-Clamp to Y-Z stage

X drive -18.0 dBV (current) accel. -101.0 dBV
⇒ 9.05×10^{-7} cm

again 12 March
clamped harder

3 clamps

Response

		again 12 March, clamped harder	ϕ		cm	response/drive	3 clamps
x(5)	-55.7 dBV	-52.8 3.14×10^{-6} 3.48	+167°	(accel turned around)	2.25×10^{-6}	2.48	3.5
y(1)	-80.0 dBV		-35°		1.37×10^{-7}	.151	.19
z(1)		1.72×10^{-7} -78. .192					
z(5)	-75.5 dBV	-74.5 2.58×10^{-7} .29	180°		2.30×10^{-7}	.254	.29
θ_x (2) vert	-79.0 dBV		180°	$\theta_x = -8.2\times10^{-10}$	1.54×10^{-7}	.170	
(3) vert	-78.0		180°		1.72×10^{-7}	.191	
θ_y (1) vert		$\theta_y \approx 1.2\times10^{-8}$					$\frac{\theta_y}{x_0} = .013$
(4) vert	-70.7 dBV	3.4×10^{-7} -72. .38	180°	$-\theta_y \approx 2.8\times10^{-8}$	3.99×10^{-7}	.442	
θ_z (2) horiz	~~-52.6 dBV~~ -56.1 dBV	~~-33°~~ -11°		$-\theta_z = 5.5\times10^{-9}$	2.14×10^{-6}	2.37	
(3) horizon	-56.6 dBV		-11°		2.02×10^{-6}	2.24	

	x	y	z	θ_x	θ_y	θ_z
x	2.5	.15	?	-9×10^{-4}	-.03	-.006
	3.5	.19	?	?	-.013	?
y						
z						

11 March 1985

Wedge Z clamp blocks underneath θ_z bearing

x drive −18.0 dBV = i, accel = −102 dBV
⇒ 1.0×10^{-6} cm

Response

			cm	response/drive	
x(1)	−56.7 dBV	−16°	2×10^{-6}	1.97	
y(1)	−81. dBV	−35°	1.22×10^{-7}	.120	
z(1)	−92. dBV	−161°	3.44×10^{-8}	.0339	
z(3)	−75.5 dBV	180°	2.3×10^{-7}	.226	
θ_x					
(2) vert	−81. dBV	180°	1.22×10^{-7}	.120	$\theta_x = -6.8 \times 10^{-10}$
(3) vert	−80. dBV	−160°	1.37×10^{-7}	.135	
θ_y					
(1) vert					
(4) vert	−68. dBV	180°	5.45×10^{-7}	.537	$-\theta_y = 3.7 \times 10^{-8}$
θ_z					
(2) horiz	−55.8 dBV	−11°	2.22×10^{-6}	2.19	
(3) horiz	−55.2 dBV	−4°	2.38×10^{-6}	2.34	$-\theta_z = -7.3 \times 10^{-9}$

	x	y	z	θ_x	θ_y	θ_z
x	1.97	.120	.03	-7×10^{-4}	−.04	−.007
y						
z						

11-March 1985

Add 1 C-Clamp to Wedges underneath θ_z bearing

X drive = −18.0 dBV − i   accel = −102 dBV
8×10^{-7} cm

Response

				cm	response/drive
x(1)	−56.9 dBV	180°	(accel turned around)	1.96×10^{-6}	2.43
y(1)	−78.8 dBV	−30°		1.57×10^{-7}	.195
z(1)	−82. dBV	−155°		1.09×10^{-7}	.135
z(5)					
θ_x					
(2) vert	−80.0 dBV	180°	$\theta_x = 1.2 \times 10^{-9}$	1.37×10^{-7}	.170
(3) vert	−81.8 dBV	−153		1.11×10^{-7}	.138
θ_y					
(1) vert			$-\theta_y = 1.1 \times 10^{-8}$		
(4) vert	−72.0 dBV	180°		3.44×10^{-7}	.427
θ_z					
(2) horiz	−58.2 dBV	−9°	$-\theta_z = 0$	1.68×10^{-6}	2.09
(3) horiz	−58.2 dBV	−15°		1.68×10^{-6}	2.09

	x	y	z	θ_x	θ_y	θ_z
x	2.43	.20	.19	.001	−.01	0
y						
z						

Wedge w/ C-Clamp underneath/near point 4, Front hinge

x_{drive} = −18.1 dBV = i_{drive} accel = −101 dBV
⇒ 9×10^{-7} cm

Response			cm	response/drive	
x(1)	−56.6 dBV	−16°	2.02×10^{-6}	2.24	
y(1)	−78.3 dBV	−27°	1.67×10^{-7}	.184	
z(1)	−82 dBV	−160°	1.09×10^{-7}	.120	
z(5)	−75.5 dBV	180°	2.30×10^{-7}	.254	
θ_x					
(2) vert	−79.5 dBV	180°	1.45×10^{-7}	.160	$\theta_x = 1.6\times10^{-9}$
(3) vert	−82. dBV	180°	1.09×10^{-7}	.120	
θ_y					
(1) vert					$-\theta_y = 2.0\times10^{-8}$
(4) vert	−71.0 dBV ~~−75.5 dBV~~	180°	3.86×10^{-7}	.427	
θ_z					
(2) horiz	−56.4	−14°	2.07×10^{-6}	2.29	$-\theta_z = -4.5\times10^{-9}$
(3) horiz	−56.0	−13°	2.17×10^{-6}	2.40	

	x	y	z	θ_x	θ_y	θ_z
x	2.24	.2	.1	.002	−.02	−.005
y						
z						

Wedge underneath X-stage cantilever (to top of flange)

X drive = −18.1 dBV = z drive   accel = −101 dBV 9×10^{-7} cm

Add C-clamp to y-z stage
Re-Shim the Wedge

Response				cm	response/drive
x(1)	−58.2 dBV	−16°		1.68×10^{-6}	1.86
y(1)	−80. dBV	−35°		1.37×10^{-7}	.151
z(1)	−86. dBV	180°		6.86×10^{-8}	.076
z(5)	−75.7 dBV	180°	−76.5 dBV	2.25×10^{-7}	.248
Θ_x					
(2) vert	−79. dBV	180°	$\Theta_x = 2\times10^{-9}$	1.54×10^{-7}	.170
(3) vert	−82. dBV	180°		1.09×10^{-7}	.120
Θ_y					
(1) vert			$-\Theta_y = 6.1\times10^{-9}$		
(4) vert	−79. dBV	180°	−74. dBV	1.54×10^{-7}	.170
Θ_z					
(2) horiz	−57.9 dBV	−14°	$-\Theta_z = -9.1\times10^{-10}$	1.74×10^{-6}	1.93
(3) horiz	−57.8 dBV	−14°		1.76×10^{-6}	1.95

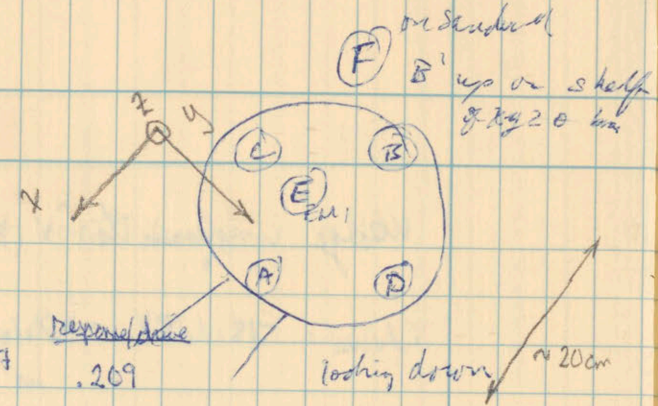
	x	y	z	Θ_x	Θ_y	Θ_z
x	1.86	.15	.08	.002	.007	−.001
y						
z						

$y = \frac{1}{2}(C+D)$
$x = \frac{1}{2}(A+B)$
$z = E$

$\theta_x = \frac{1}{2}(D-C)\frac{1}{20cm}$

$\theta_y = \frac{1}{2}(B-A)\frac{1}{20}$

$\theta_z = \frac{1}{2}(B-A)\frac{1}{20}$



Measure on Flange

			cm	response/drive
A (vert)	−77.2 dBV	180°	1.89×10^{-7}	.209
B' (vert)	−86. dBV	−150°	6.86×10^{-8}	.076
C (vert)	−88.5 dBV	180°	5.15×10^{-8}	.057
D (vert)	−77. dBV	180°	1.93×10^{-7}	.214
z = E (vert)	−79. dBV	180°	1.54×10^{-7}	.170
B' (radial)	−63.2 dBV	−18°	9.47×10^{-7}	1.05
A (radial)	−63.6 dBV	−18°	9.05×10^{-7} (makes sense, actually anti-radial)	1.00
C (anti radial)	−76.2 dBV can null to	180°	2.12×10^{-7}	.234
D (radial)	−90.0 dBV		4.33×10^{-8}	.048
B' (tangential)	−88. dBV	−150°	5.45×10^{-8}	.060
A (tangential)	−73. dBV	180°	3.06×10^{-7}	.339

$\theta_y = 1.3\times10^{-9}$

$\theta_x = 3.5\times10^{-9}$

$z = 9.3\times10^{-7}$

$y = 1.3\times10^{-7}$

$\theta_z = -6.3\times10^{-9}$

Measure on Sandwich

			cm	response/drive
B (radial)	−77.6 dBV	180°	1.93×10^{-7}	.214
A (radial)	−81.	180°	1.22×10^{-7}	.135
C (radial)	−78.6	180°	1.61×10^{-7}	.178
D (radial)	−80.0	180°	1.37×10^{-7}	.151
~~A~~B (tangential)	−79.	180°	1.54×10^{-7}	.170
A (tangential)	−78.0	180°	1.72×10^{-7}	.191
B (vert)	−85	−160°	7.70×10^{-8}	.085
A (vert)	−76	180°	2.17×10^{-7}	.240
C (vert)	−80.	180°	1.37×10^{-7}	.151
D (vert)	−79.	180°	1.54×10^{-7}	.170
F (vert)	−86	−160°	6.86×10^{-8}	.076

$\theta_y = -3\times10^{-9}$

$\theta_x = 3.4\times10^{-10}$

11-March-85

for flange:

	x	y	z	θ_x	θ_y	θ_z
x	1.0	.14	.17	.004	-.003	-.007
y						
z						

Summary for f = 47.2 Hz data

11-March-85

conditions	x	y	z	θ_x	θ_y	θ_z	
"as is"	2.3	.20	.05	.01	-.03	-.01	
x stage clamped	1.9	.05	.05	.002	-.02	0	
yz stage clamped	2.5	.15	?	-.0009	-.03	-.006	
θ_z wedged ~~clamped~~	1.97	.12	.03	-.0007	-.04	-.007	
θ_z wedged + clamped	2.43	.20	.14	.001	-.01	0	← ?
θ screw wedged + clamped	2.24	.2	.1	.002	-.02	-.005	
x cantilever clamped	1.86	.15	.08	.002	.007	-.001	←

12-March-85

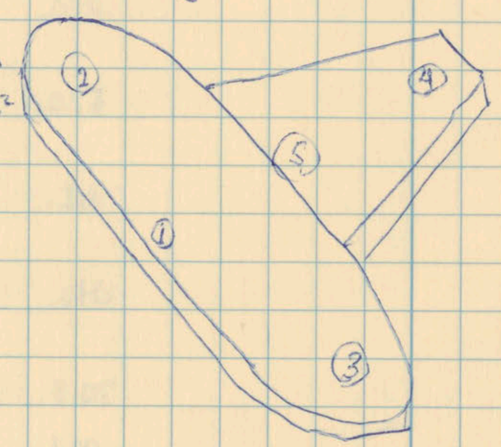
Fiddle a bit with high frequencies - find that, with driving point at the shelf, need to stiffen sandwich. Decide to lif the y direction.

y drive: $f = 47.2$ Hz $m = F/a =$ ~~9kg~~ 374 kg

$i = 123$ mV $F = 4.2 \times 10^4$ dynes

$a =$ ~~-68.8 dBV~~ $\Rightarrow$ ~~5.2×10^{-5} cm~~ 1.3×10^{-6} cm

-98.0 dBV $\Rightarrow$ ~~4.6 cm/sec²~~ 1.1×10^{1} cm/sec²



	Response	dBV	ϕ	cm	response/drive		
	x(1)	-75.5	180	2.3×10^{-7}	~~.004~~	.18	
	y(1)	-55.4	-16°	2.3×10^{-6}	~~.05~~	1.80	
	z(1)	-82.5, -79.	180°	1.03×10^{-7}	~~.002~~	.08	
	z(5)	-77., -77.	180°	1.93×10^{-7}	~~.004~~	.15	
	z(4)	-77., -79.	-170°	1.93×10^{-7}	~~.004~~	.15	
θ_x	(2) vert	-69.3	+170°	4.7×10^{-7}	~~.009~~	.36	$\theta_x = 1.2 \times 10^{-8}$
	(3) vert	-76.5	-25°	2.05×10^{-7}	~~.004~~	.16	
θ_y	(1) vert						$-\theta_y = 6.43 \times 10^{-9}$
	(4) vert						
θ_z	(2) hor	-68.8 dBV	180°	4.97×10^{-7}	~~.010~~	.38	$-\theta_z = 1.4 \times 10^{-8}$
	(3) hor.	-77.2 dBV	+154°	1.89×10^{-7}	~~.004~~	.145	

"as is" matrix

drive \ response	x	y	z	θ_x	θ_y	θ_z
x	2.3	.20	.05	.01 cm⁻¹	-.03 cm⁻¹	-.01 cm⁻¹
y	.18	1.8	.08	.009 cm⁻¹	-.005 cm⁻¹	-.011 cm⁻¹
z						

Now wedge underneath X-stage cantilever

y drive

	Response	ϕ	cm	response/drive	
x(1)	-70.	180°	4.33×10^{-7}	.33	
y(1)	-56.3	-17°	2.1×10^{-6}	1.61	
z(1)	-79.	180°	1.54×10^{-7}	.12	
z(5)	-77.	180°	1.93×10^{-7}	.15	
z(4)	-77.	180°	1.93×10^{-7}	.15	
θ_x (2) vert	-69.	180°	4.86×10^{-7}	.37	$\theta_x = 1.93 \times 10^{-8}$
(3) vert	-78.	-5°	1.72×10^{-7}	.13	
θ_y (1) vert					$-\theta_y = 2.8 \times 10^{-9}$
(4) vert					
θ_z (2) horiz	-70.	180°	4.33×10^{-7}	.33	$-\theta_z = 1.09 \times 10^{-8}$
(3) horiz	-77.	180°	1.93×10^{-7}	.15	

	x	y	z	θ_x	θ_y	θ_z
x						
y	.33	1.6	.12	.011	-.002	-.008
z						

C-Clamp the living shit out of Y-Z -stage, see p. 13

$$\frac{F_{acc}}{F_{appl \text{ at bottom of stack}}} = \frac{3.3\times10^{-2}\ \text{dyne}/\text{cm}^2 \left(\overset{38.7\ \text{cm}^2}{6\ \text{in}^2 (2.54)^2}\right)}{(44.7\ \text{cm/sec}^2)(4700\ \text{gms})} = \frac{1.28\ \text{dynes acc}}{2.1\times10^5\ \text{dynes mech}} = 6.1\times10^{-6}$$

$a_{top} = 1.2\times10^{-3}\ \text{cm/sec}^2$

$m a_{top} = 5.6$ dyne $\sim$ 1.3 dyne

Ambient acoustic pressure noise in room

$2.6\times10^{-2}\ \text{dynes/cm}^2 \times 130\ \text{cm}^2 = 3.4$ dyne

$m = 4\times10^3\ g$

check 6.WS

Nov25C.SP1
another measurement $-55\ \text{dBV}/\sqrt{\text{Hz}}$ from microphone

$2.6\times10^{-3}\ \text{dynes/cm}^2\sqrt{\text{Hz}} \times 130\ \text{cm}^2 = 3.4\times10^{-1}\ \text{dyne}/\sqrt{\text{Hz}}$ acoustic

$\div 4\times10^3 g \Rightarrow a_{acoustic} = 8.5\times10^{-5}\ \text{cm/sec}^2\sqrt{\text{Hz}} \approx 10^{-4}\ \text{cm/sec}^2\sqrt{\text{Hz}}$

Nov10A. no accel. 1.1×10^{-3}. $\text{cm/sec}^2\sqrt{\text{Hz}}$

Actual motion vs. acoustical noise for Ling + Room 3/19/85

from Suspensions I p. 76:

$\sim$ 300 Hz, see -46 dBV/$\sqrt{Hz}$ motion with ~ 33 dBV/$\sqrt{Hz}$ sound

$\Rightarrow$ 44.7 cm/sec^2/$\sqrt{Hz}$ $\Rightarrow$ $3.3 \times 10^{-2} \frac{dyne}{cm^2 \sqrt{Hz}}$

.68 V/μbar
$\approx$ .68 V/dyne/cm^2

using .1098 V/g, 980 cm/sec^2/g

so $\frac{\text{acoustic noise}}{\text{acceleration}} = \frac{3.3 \times 10^{-2} \text{ dyne/cm}^2/\sqrt{Hz}}{44.7 \text{ cm/sec}^2/\sqrt{Hz}} \approx \boxed{7.36 \times 10^{-4} \frac{dyne \cdot sec^2}{cm^3} \text{ for Ling}}$

from Jan 31, 1984, typical room noises:

$\sim$ 0 - 200 Hz -45 dB~~V~~ $\rightarrow$ 8.3×10^{-3} dyne/cm^2

200 - 600 Hz -35 dB~~V~~ $\rightarrow$ 2.6×10^{-2} dyne/cm^2

from Nov 10 D, 1984, typical accelerations

0 - 200 Hz ~ -80 dBV $\Rightarrow$ ~~.89~~ 1.2×10^{-2} cm/sec^2

200 - 600 Hz -75 dBV $\Rightarrow$ ~~1.59~~ 2.14×10^{-2} cm/sec^2

so $\frac{\text{acoustic}}{\text{acceleration}} = \frac{8.3 \times 10^{-3}}{.89} = \cancel{9.3 \times 10^{-3}}\ 6.9 \times 10^{-1} \frac{dyne \cdot sec^2}{cm^3}$ 0 - 200 Hz for room

$\frac{\text{acoustic}}{\text{accel}} = \frac{2.6 \times 10^{-2}}{1.59} = \cancel{1.6 \times 10^{-2}}\ 1.2 \frac{dyne \cdot sec^2}{cm^3}$ 200 - 600 Hz for room

Calibrations

Endevco 7707

MOVING ACC.

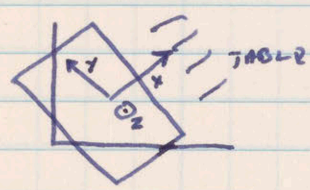
$\text{cm}/\text{sec}^2/\text{V} = 120.4$

$\text{cm}/\text{V} = \dfrac{3.05}{f^2}$

FORCER

$F/i = 3.4 \times 10^5$ DYNES/AMP

	cm/V DC	128 Hz		AT MIXER OUTPUT
	cm/V	G	cm/V	
X	CAL MARCH 1.2×10^{-2}	38	3.2×10^{-4}	
Y	CAL MARCH 9.3×10^{-3}	34	2.7×10^{-4}	
Z	CAL MARCH 2.1×10^{-2}	1.9	1.1×10^{-2}	



Calibration

Calibration factors:

Endevco 7707:

$120.4 \ \frac{cm/sec^2}{V}$

$\frac{3.05}{f^2} \ cm/V$

2271:

$8925.3 \ \frac{cm/sec^2}{V}$

$\frac{226.1}{f^2} \ cm/V$

plates	DC cm/V	G	cm/V
x - CMO	1.2×10^{-2}	38	3.2×10^{-4}
y - CMO	9.3×10^{-3}	34	2.7×10^{-4}
z - CMO	2.1×10^{-2}	19	1.1×10^{-2}