Mass

7530-286-6952

FEDERAL SUPPLY SERVICE

GPO: 1964—O-727-185

Measurement of mass under Zero G conditions –

Most of the methods proposed so far depend upon 1) making the mass part of an oscillatory system by the addition of a compliance and measuring periods: $\frac{1}{T} \simeq \frac{1}{\sqrt{2\pi MC}}$

2) ~~spinning it~~ placing the mass in a circular orbit and measuring the force developed.

$$F = \frac{\frac{1}{2} mV^2}{R}$$

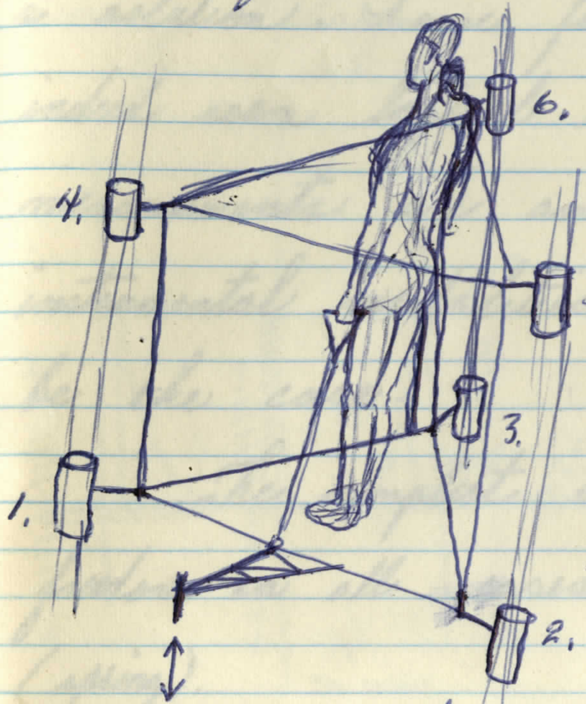
3)

2. The difficulties c̄ method 1) ~~differeno~~ lack of complete coupling of all parts of a man's body.

2) variations in distribution of mass as a function of length during measurement

Reference to 2.1 —
Coermann et al. Luftfahrtforsch. V 3 P 111 1938 — see also V-III P-663 668 Medical Physics show that deviation from linearity (m ω) is negligible below 3 CPS when sitting c̄ abdominal restraints.

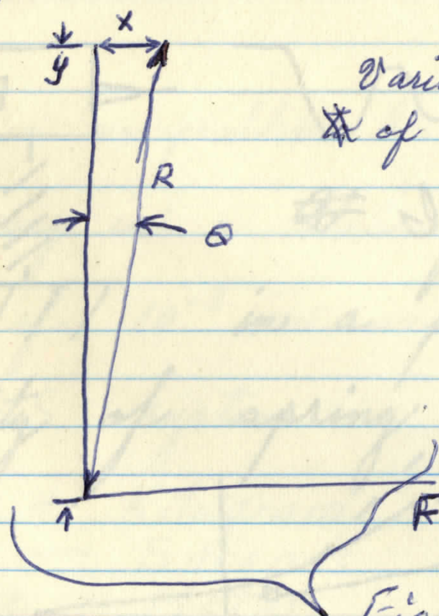
It would seem hopless to attempt to solve the problem $\equiv$ restraining the mass to a single degree of freedom. In addition a reduction in the motion of individual body components may be effected -



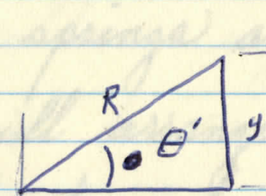
1-6 are low friction bearings to restrain the platform to a single degree of freedom - (Vertical)

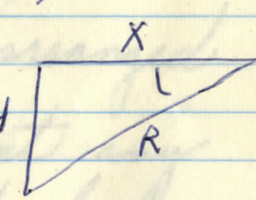
Not to SCALE or Proportion

Force attachment point & plane



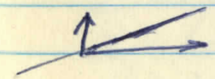
Variations of force as a function of variation from a given plane





$F = R - y$ $\quad$ $\cancel{R = \tan \frac{y}{x}}$

Fig. 1 $\left\{ \cos\theta = \frac{X}{r} \quad r = \frac{X}{\cos\theta} \right.$



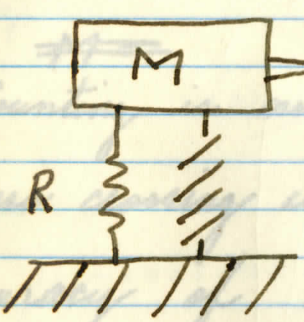
R = Force applied $\quad$ Y = resulting Force in Y plane

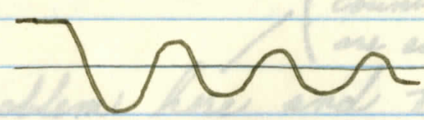
R

$1^\circ = .9998 \quad 2^\circ 30' = .999$ (.1%)

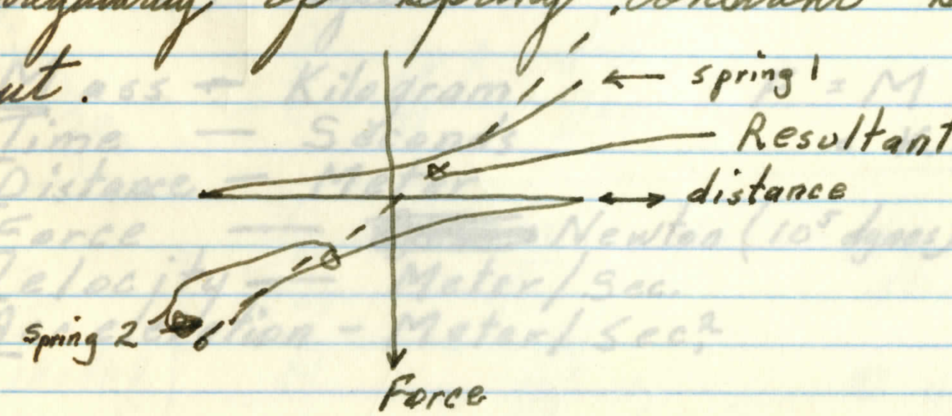
At first ~~of~~ glance an analog of ~~capacitor~~ L.C.R. circuit measurements might seem most logical for a solution. Some form of frequency determination would indeed seem logical since time & frequency measurements are among our most accurate instrumental modalities. This however may not be the case-

The simplest case is (assuming 1 degree of freedom in all cases) addition of a compliance (spring).

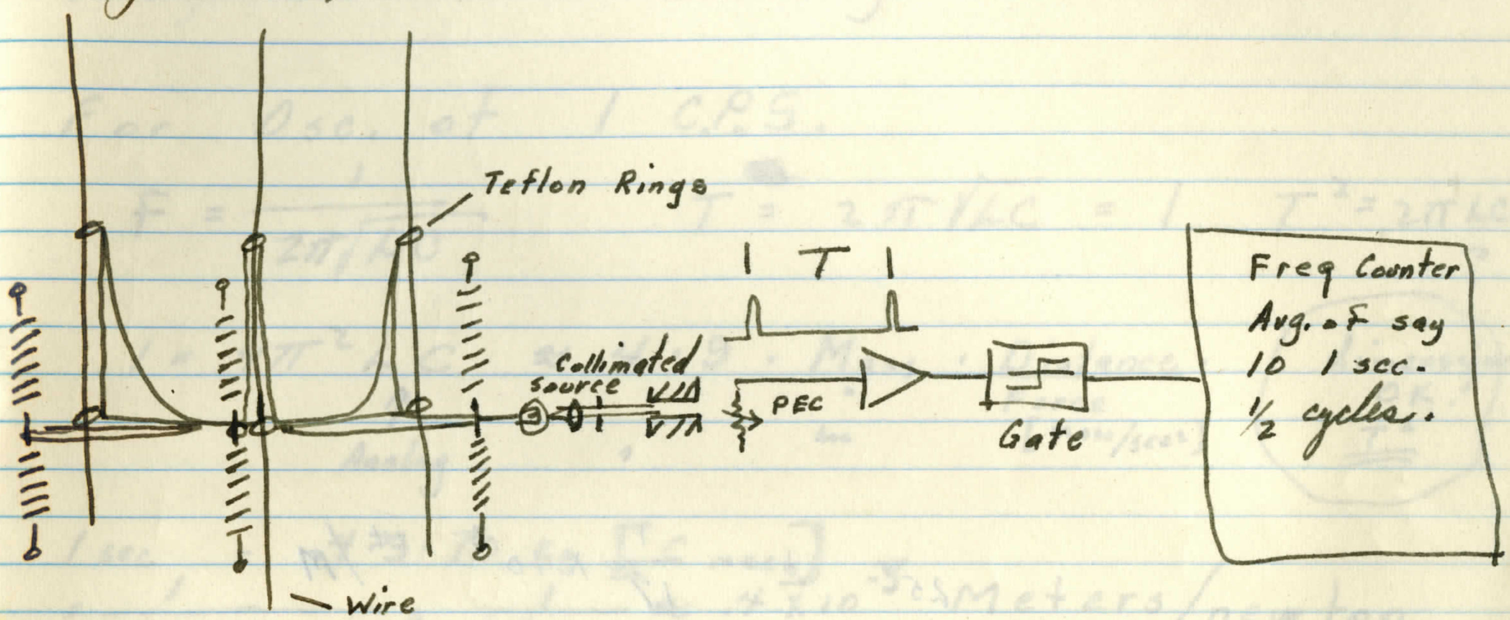




~~#~~ If the springs are arranged in a push-pull arrangement any irregularity of spring constant should balance out.



A displacement could be applied and the frequency of the resultant damped oscillation measured by timing techniques.



$T \sim \sqrt{M}$

~~M~~

(counting accuracies of 5×10^{-5} are easily available)

Counting is no problem here and the detection of zero crossing is a mechanical problem - say an accuracy of 10^{-3} ins. and should be realized easily.

In MKS system -

Mass - Kilogram $F = M A$
Time — Seconds $= Kg. \cdot Meter/sec^2$.
Distance - Meter
Force — ~~Dyne~~ Newton (10^5 dynes)
Velocity — Meter/Sec.
Acceleration - Meter/Sec.^{2}

$$C_{\text{comp.}} = \frac{\text{Distance}}{\text{Force}} = \text{Meters}/\text{Newton} \qquad \frac{Q}{V} = \cancel{Q}V \quad E = IR$$

$$\underline{M}\text{ass} = \underset{(\text{Newton})}{\text{Force}} \times \underset{(M/sec^2)}{\text{Acceleration}}$$

$$\text{Resistance} = \underset{(\text{Newton})}{\text{Force}} / \underset{(M/sec)}{\text{Velocity}}$$

Distance – Charge
Velocity – Current
Acc. – Rate of ch. I
Force – ~~E~~ Volt.

For Osc. of 1 C.P.S.

$$F = \frac{1}{2\pi\sqrt{LC}} \qquad T = 2\pi\sqrt{LC} = 1 \qquad T^2 = 2\pi LC \; ?$$

$$1 = 4\pi^2 LC \approx 4 \cdot 9 \cdot \text{Mass} \cdot \frac{\text{Distance}}{\text{Force}} \cdot$$

↑ Analog

Force [mass/sec²]

dimensions O.K.! $\underline{\underline{T^2}}$

$$1\,\text{sec} = 4 \cdot 9 \cdot 70\ \text{kg}\ [C_{\text{mech}}]$$

$$= \frac{1}{36 \times 70} = \frac{1}{2520} \approx .4 \times 10^{-3}\ \text{Meters/newton}$$

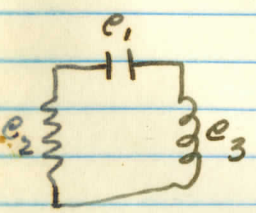
$$\approx 1.7 \times 10^{-3}\ \text{Meters}/\#$$

$$F^2 = \frac{M\,L}{M\,T^2}$$

$$(N \cdot \cancel{M}/sec^2) \cdot \frac{M}{\underset{M}{(N \cdot M/sec^2)}\ \underset{A}{(M/sec^2)}}$$

CK Dimensions –

Analog



$$\frac{Q}{C} + \frac{dQ}{dt}R + \frac{d^2Q}{dt^2}L = 0$$

$Q = CV$

$$e_1 = \frac{Q}{C}$$

$$e_2 = IR = \frac{dQ}{dt}R$$

$$e_3 = \frac{dI}{dt}L = L\frac{d^2Q}{dt^2}$$

$$\frac{X}{\text{Cap}} + \text{Res}\,\frac{dx}{dt} + \text{Mass} \cdot \frac{d^2X}{dt} = 0$$

$$\frac{\cancel{M}}{\cancel{M}/N} + \frac{dM}{dt}\,N/M/s + N/M/s^2 \cdot M/s^2$$

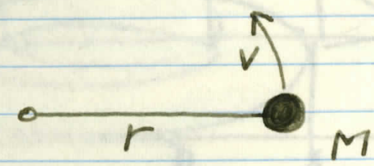
Equivalents:

1 Newton = 10^5 Dynes = 3.60 oz

$1^{\#}$ = 4.448 Newtons

1 gm. wt. = 980 dynes

Effects of a rotating wt.



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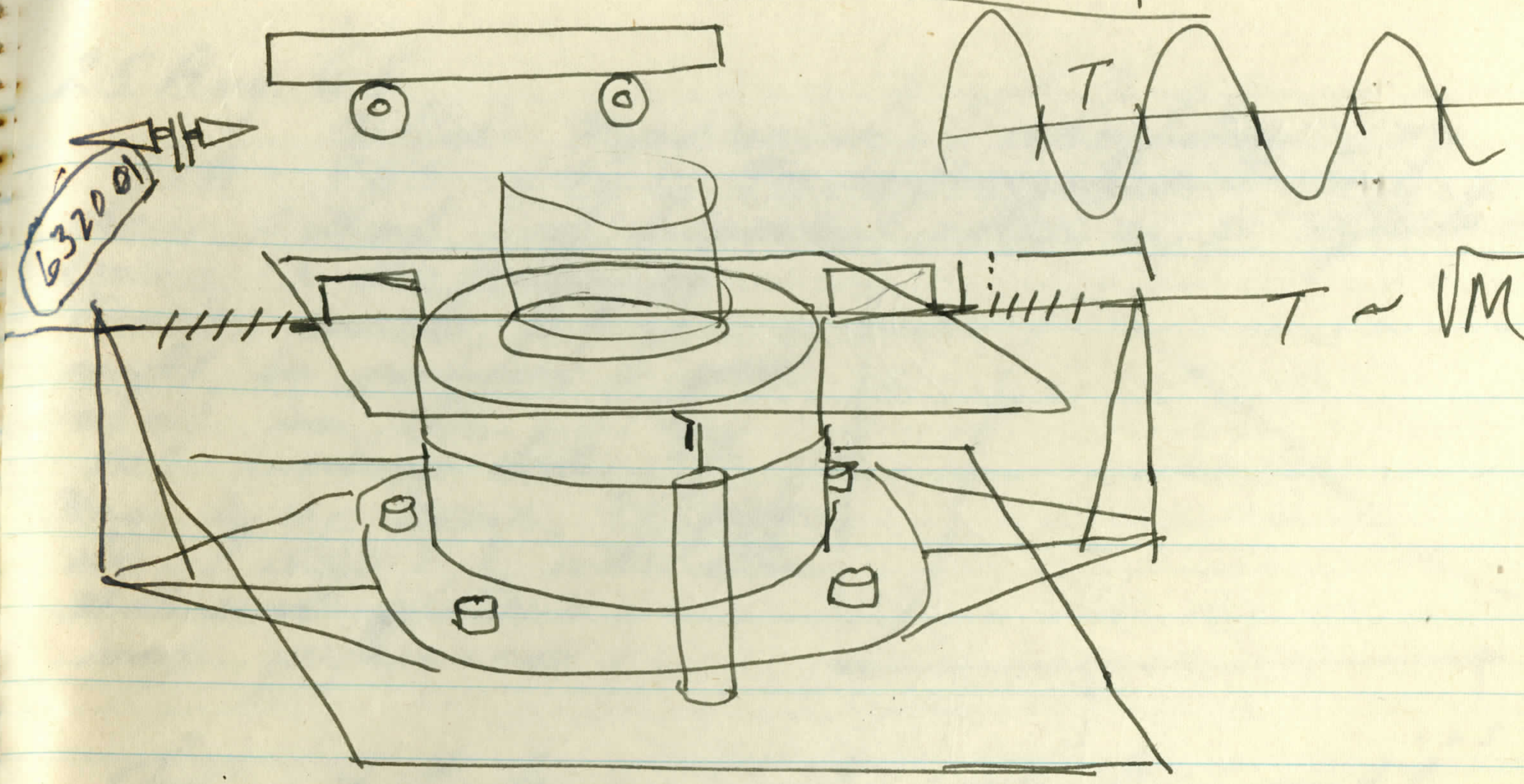
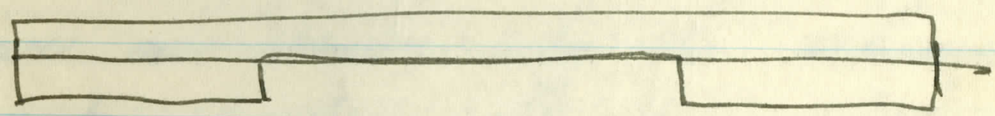
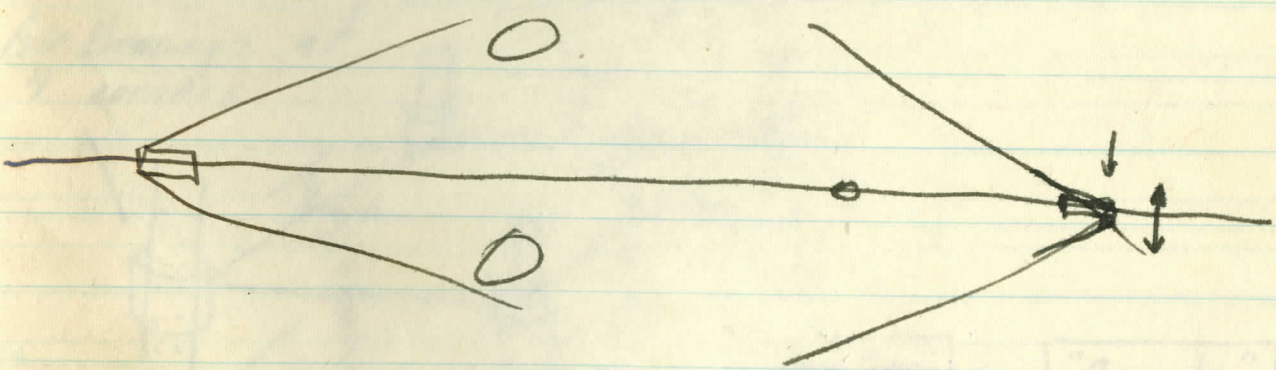


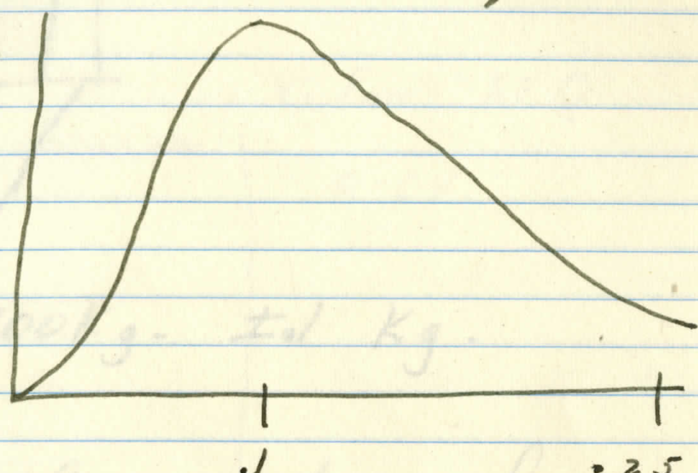




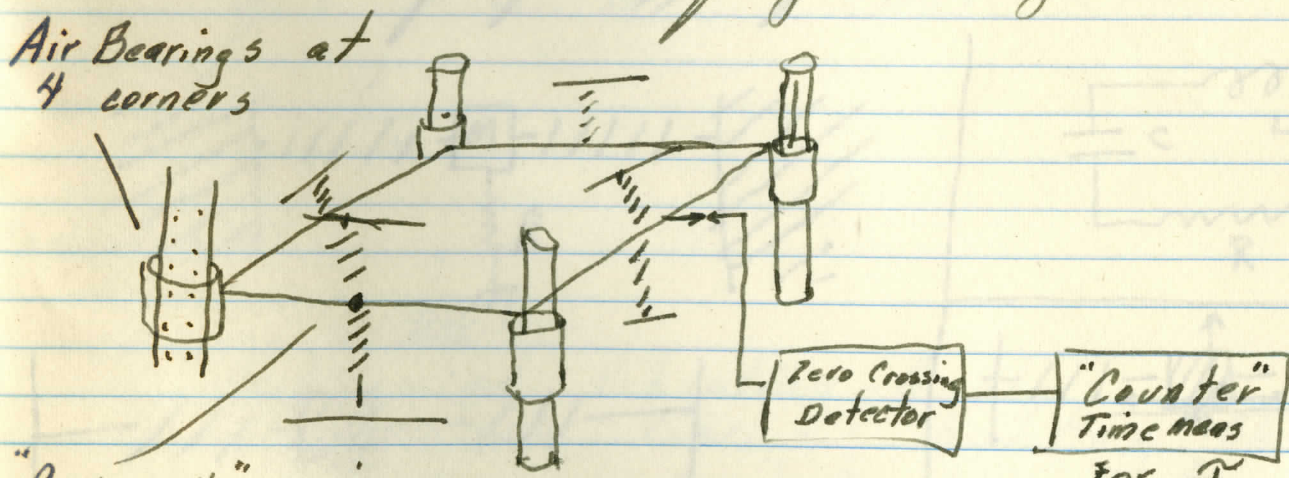
locked onto posn. when not in use.

25 Aug. 65

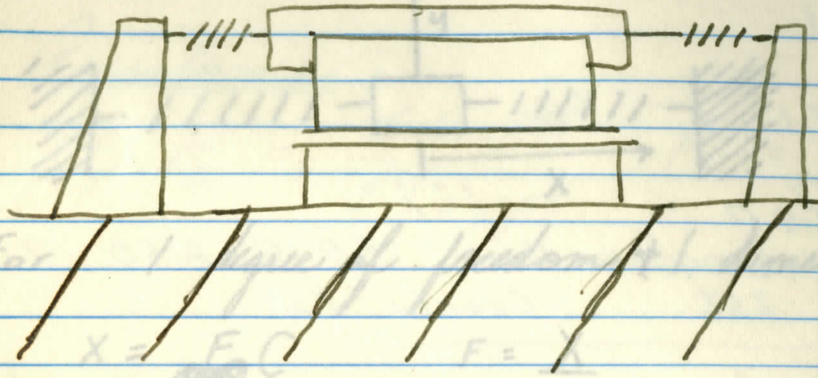
Called Mechanical Technology Inc. 518-785-0922 Mr. Springstead about their Optical Dist. Sensors which is a reflectance device c̄ the following transfer curve but might be modified to yield 1/2 mil res. at 1/4" working dist. 2V. Has 2 mV. noise, 1/4" probe. std., $1000 + 2 wks. deliv. Will send quotes + max. performance.



~~The~~ Will do a simple exploratory model using the air bearing as soon as possible. Can see no reason why the scheme below will not work in flight (weightless)



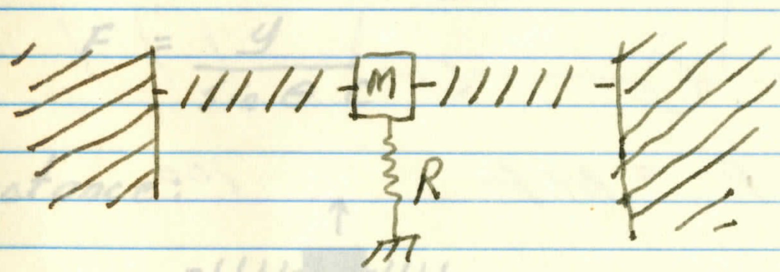
Such an arrangement could be incorporated into a normal seat which would be locked into posn. when not in use.

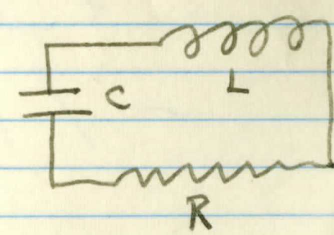


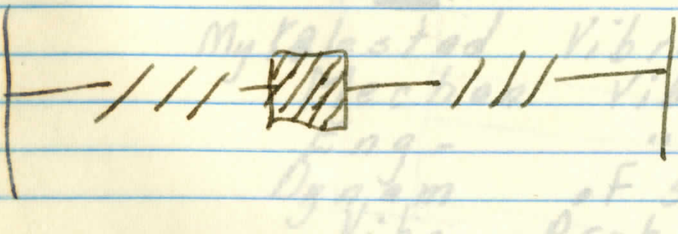
Range of Mass. 50-100 Kg. ±.1 Kg.

Accuracy <u>.1 %</u>

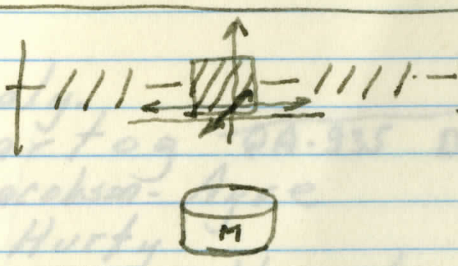
Method: determination of period c̄ the unknown mass made a portion of ~~the~~ an oscillating system at a nominal frequency of <u>1 C.P.S.</u> .



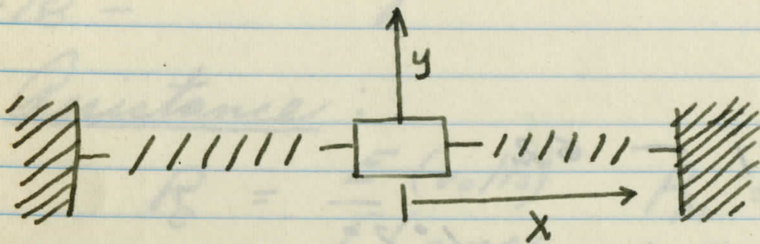




Quigly . Hughes



→Earl Bell←



For 1 degree of freedom + 1 dimension:

$X = F C$ $\qquad F = \frac{X}{C}$

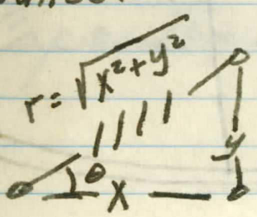
$F = \dot{X} R$

V: Force $\quad X \doteq Q$

$Q = CV$

For 2 ~~degrees:~~ dimensions:

Capacitance:



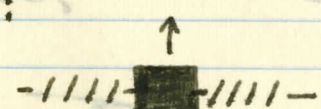
$\sin\theta = \frac{y}{r}$

$\cos\theta = \frac{x}{r}$

$y = F \sin\theta\, C$

$F = \frac{y}{\sin\theta\, C}$

Inductance:



Myklestad Vibration-Analy.
Mechan Vibr. - Hartog ~~QA-935 D3~~
Eng- " - Jacobson-Ayre
Dynam of Struct - Hurty
Vibr. Prob. in Eng.- Timoschenko

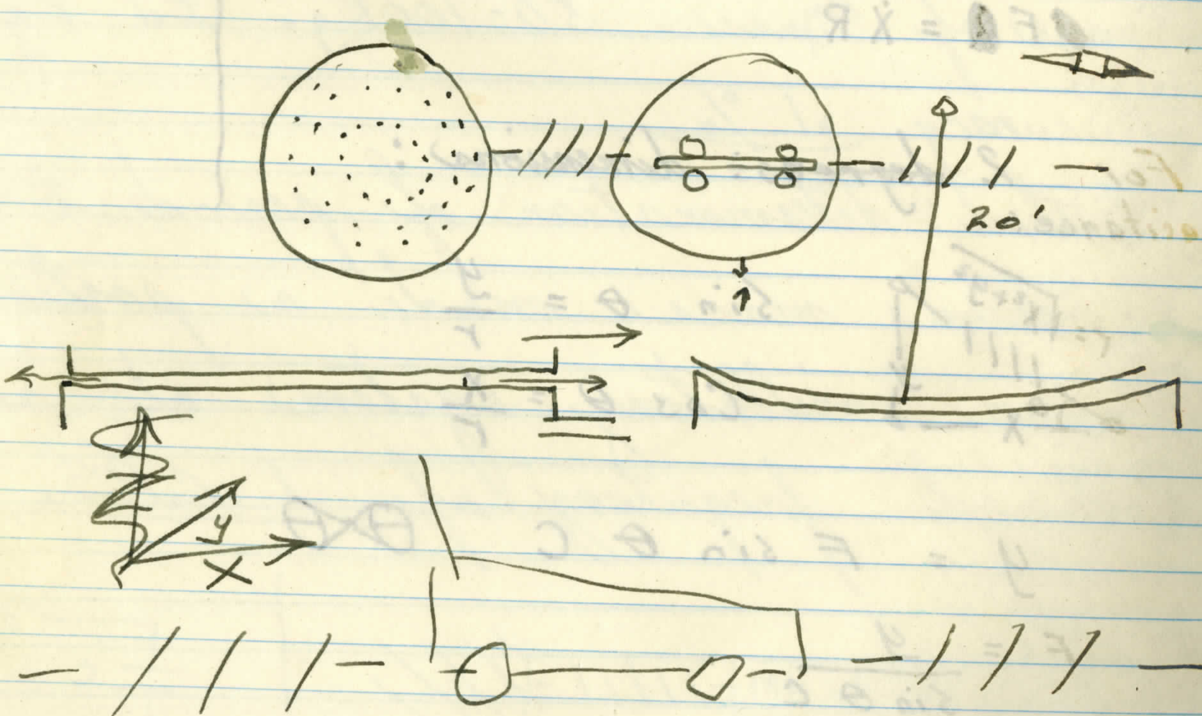
RC-1100 S-72 $\quad$ Coermann
~~QA-871 C-72~~ $\quad$ QA 871 K82
RC-1125 H-27 $\quad$ TA-355 M74
TA-355 H27 $\quad$ QA-935 T4

Nortronics -
213 · 772 · 2321
Hughes -
213 · 391 · 0711 — 62

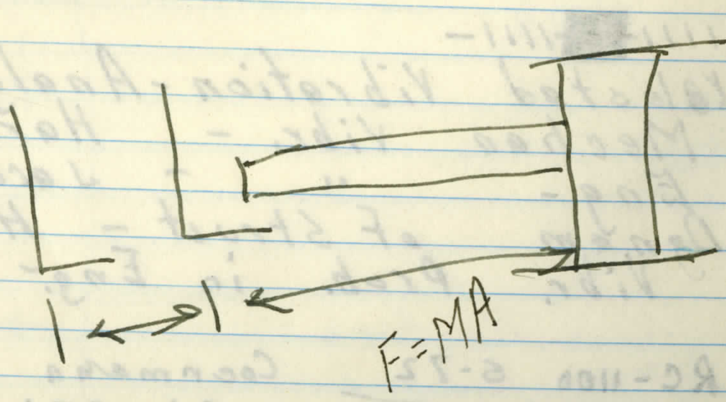
Paul Crafton · 1°2°
Geo. Washington Univ. FE 80250 · 202
Ext. 255 Cronin · 721

Dept. Mech.

Sgt.



F = MA 100



From Olson, Dynamical Analogies:
P-18 -

<u>Resistance</u>:

$$R_e = \frac{E\,(\text{volts})}{I\,(\text{amps}}\qquad R_m = \frac{F\,(\text{dynes}_{cgs} -}{\dot{X}\,(\text{cm/sec}_{cgs} -}$$

<u>Inductance</u>:

$$E_{(\text{volts})} = L_e \frac{dI}{dt}\left(\frac{\text{Amp}}{\text{sec}}\right)\qquad F(\text{dynes}) = M(\text{grams})\,\frac{d^2x}{dt^2}\left(\text{cm/sec}^2\right)$$

& $L_e = E($

Capacitance