

1978 M3

a. $\tau = r_{\perp} F$ WHERE $r_{\perp} = l \cos \theta \approx l$
 $F = -kx = -kl \sin \theta \approx -kl\theta$

$$|\tau| = (l)(kl\theta) \\ = kl^2\theta$$

b. $\tau = I \alpha$ WHERE $I = 2(ml^2)$

$$\alpha = \frac{kl^2\theta}{2ml^2} = \frac{k\theta}{2m}$$

c. $\frac{d^2\theta}{dt^2} = -\frac{k}{2m} \theta$

d. $\theta = -\theta_0 \cos\left(\sqrt{\frac{k}{2m}} \cdot t\right)$

1989 M3

a. $v_f^2 = v_i^2 + 2a\Delta s$

$$v_f = \sqrt{2g\Delta s} = \sqrt{2(9.8)(0.45)} = 2.97 \text{ m/s}$$

b. $T = 2\pi \sqrt{\frac{m}{k}} = 2\pi \sqrt{\frac{2}{200}} = 0.628 \text{ s}$

c. v_{max} occurs when $mg = ky$
 $(2)(9.8) = (200)(y)$

$$y = 0.098 \text{ m}$$

d. $mgh = \frac{1}{2}kx^2$

$$mg(0.45 + x) = \frac{1}{2}kx^2$$

$$(2)(9.8)(0.45 + x) = \frac{1}{2}(200)x^2$$

$$8.82 + 19.6x = 100x^2$$

$$100x^2 - 19.6x - 8.82 = 0$$

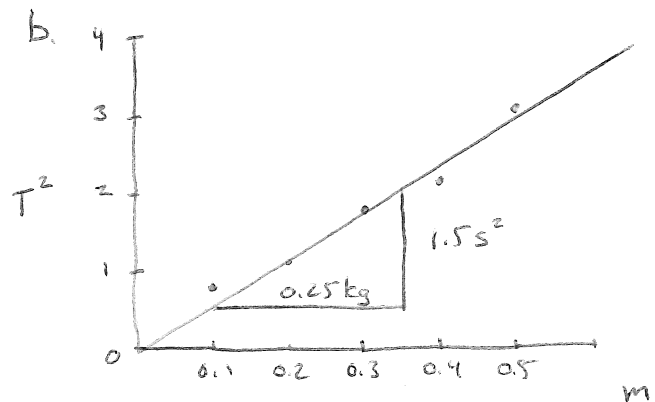
$$x = 0.411 \text{ m}$$

e. $A = 0.411 - 0.098 = 0.313 \text{ m}$

1996 m1

a.

T (s)	T ² (s ²)
0.886	0.785
1.06	1.12
1.35	1.82
1.47	2.16
1.77	3.13



c. 0.45 kg

d. $T = 2\pi \sqrt{\frac{m}{k}}$

$$T^2 = 4\pi^2 \left(\frac{m}{k} \right)$$

$$\frac{T^2}{m} = \text{SLOPE} = \frac{4\pi^2}{k}$$

FIND THE SLOPE AND SOLVE FOR K.

e. YES. THE OSCILLATIONS ARE INDEPENDENT OF THE GRAVITATIONAL FIELD OR EFFECTIVE GRAVITATIONAL FIELD IN WHICH THE MEASUREMENTS ARE MADE.

f. $g = \frac{GM_E}{R^2} = \frac{(6.67 \times 10^{-11}) \cdot (6.0 \times 10^{24})}{(6.4 \times 10^6 + 0.3 \times 10^6)^2}$

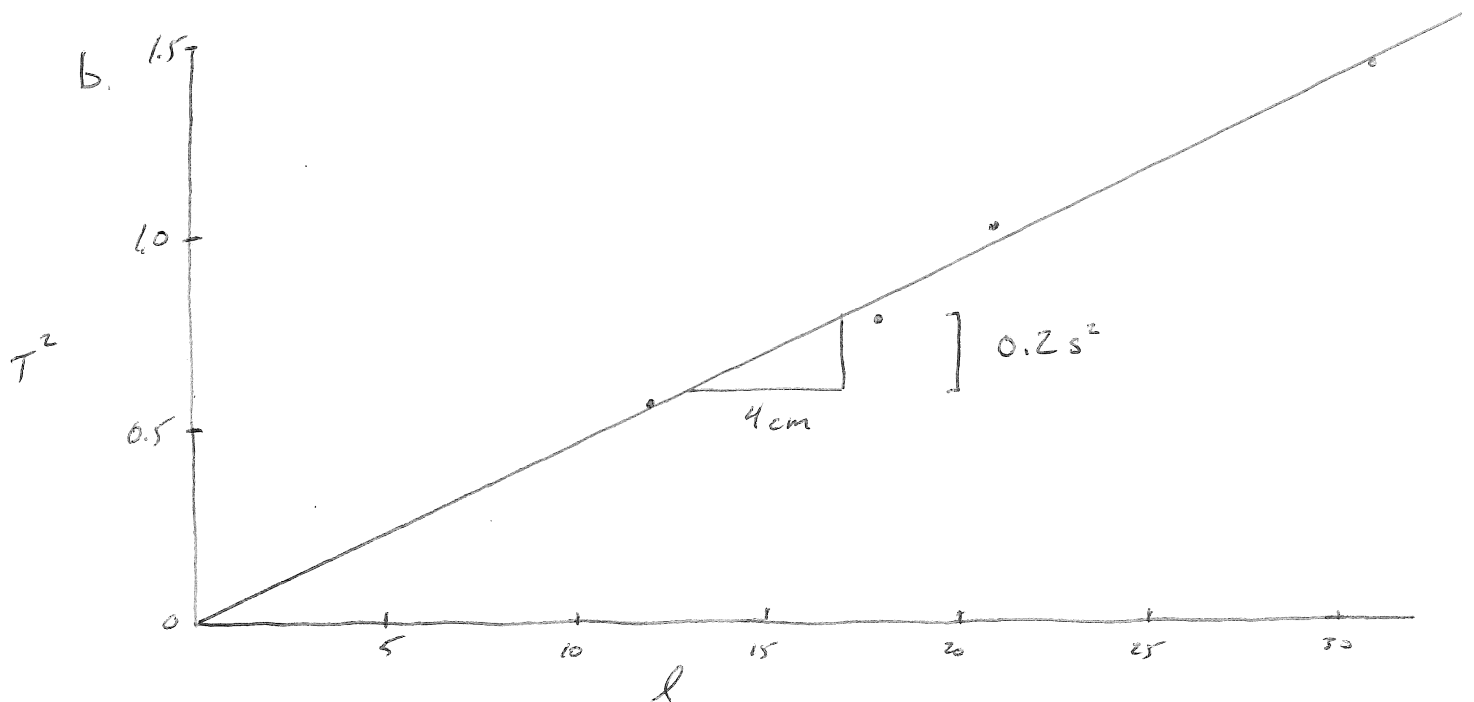
$$= 8.915 \text{ m/s}^2$$

g. THEY ARE IN CONSTANT FREEFALL TOWARDS THE EARTH.

2000 ml

a.

T (s)	T^2 (s ²)
0.762	0.581
0.889	0.790
1.009	1.018
1.208	1.459



c. $T = 2\pi \sqrt{\frac{l}{g}}$

$$T^2 = 4\pi^2 \left[\frac{l}{g} \right]$$

$$\frac{T^2}{l} = \frac{4\pi^2}{g} = \frac{0.2}{4}$$

$$g = 790 \text{ cm/s}^2 \\ = 7.90 \text{ m/s}^2$$

d. % error = $\frac{|9.8 - 7.9|}{9.8} = 19\%$

THIS IS OUTSIDE 4%.

e. $g_{\text{EFFECTIVE}} = g_{\text{EARTH}} + a$

$$7.9 = 9.8 + a$$

$$a = -1.9 \text{ m/s}^2$$

so 1.9 m/s² DOWNWARDS

2009 M2

a. i. $\tau = I\alpha$

$$x Mg \sin \theta = - I \frac{d^2 \theta}{dt^2} \quad \text{AND } \sin \theta \approx \theta$$

$$\frac{d^2 \theta}{dt^2} + \frac{Mgx}{I} \theta = 0$$

ii. $\theta = \theta_0 \cos(\omega t)$

$$\omega_{\text{rot}} = -\theta_0 \omega \sin(\omega t)$$

$$\alpha = -\omega^2 \theta_0 \cos(\omega t) = -\omega^2 \theta$$

$$\omega^2 = \frac{Mgx}{I} \quad \text{so} \quad \omega = \sqrt{\frac{Mgx}{I}}$$

$$T = \frac{2\pi}{\omega} = 2\pi \sqrt{\frac{I}{Mgx}}$$

b. OSCILLATE THE BAR AT A SMALL ANGLE MANY TIMES TO FIND \bar{T} . SET THIS EQUAL TO THE EQUATION ABOVE AND SOLVE FOR I .

c. TAKE A SOLID CONE AND FIND THE POINT OF THE BAR WHICH BALANCES ON THE POINT OF THAT CONE. THIS IS THE BAR'S CENTER OF MASS.

2011 m3

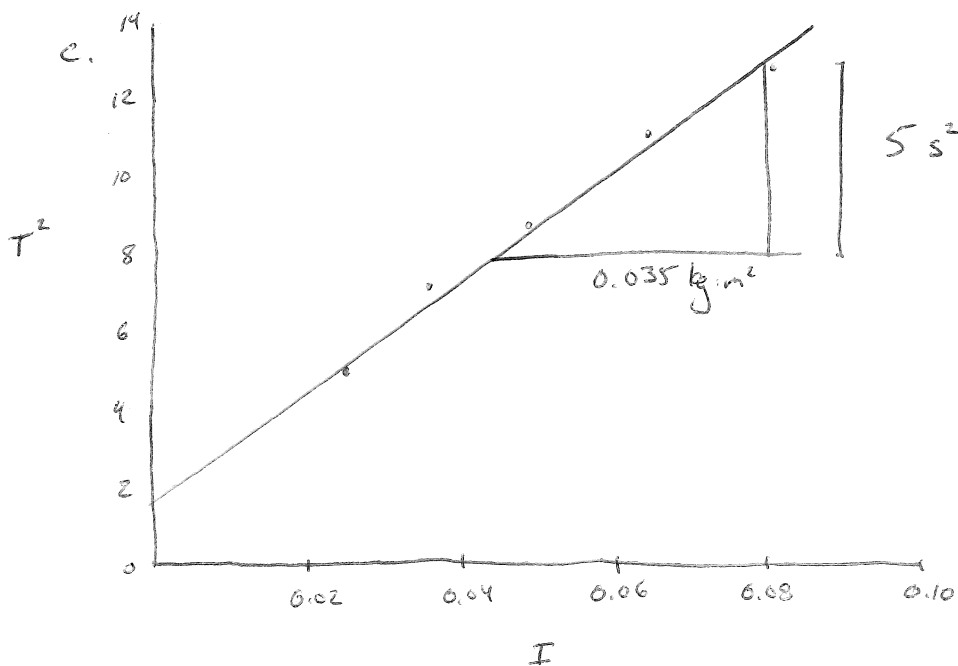
a. $\tau = I\theta$

$$-B\theta = I \cdot \frac{d^2\theta}{dt^2}$$

$$\frac{d^2\theta}{dt^2} + \frac{B}{I}\theta = 0$$

b. $\frac{d^2s}{dt^2} = -\frac{k}{m}s$ Ans $T = 2\pi\sqrt{\frac{m}{k}}$

$$\frac{d^2\theta}{dt^2} = -\frac{B}{I}\theta \quad \text{so } T = 2\pi\sqrt{\frac{I}{B}}$$



d. $y = mx + b$

$$T^2 = 143 \cdot I + 1.5$$

e. $T = 2\pi\sqrt{\frac{I}{B}}$

$$\frac{T^2}{I} = \frac{4\pi^2}{B} = 143$$

$$T^2 = 4\pi^2 \frac{I}{B}$$

$$B = 0.276 \text{ N}\cdot\text{m}$$

f. IT IS THE PERIOD-SQUARES OF THE ROD OSCILLATING ALONE

2012 m1

a. $\omega = \frac{2\pi}{T} = \frac{2\pi}{0.7} = 9 \text{ rad/s}$

$$v = -0.16 \sin(9t)$$

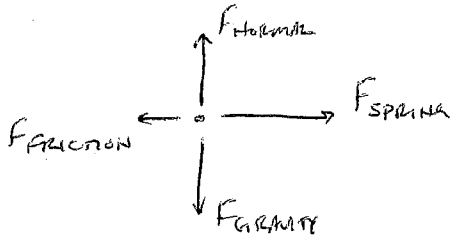
b. $x = \int -0.16 \sin(9t) dt$
 $= 0.018 \cos(9t)$

c. $\omega = \sqrt{\frac{k}{m}}$

$$9 = \sqrt{\frac{k}{0.3}}$$

$$k = 24.3 \text{ N/m}$$

d. TOWARDS



AWAY FROM

