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 $I = 2(ml^2)$

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

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

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

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

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

$8.82 + 19.6x = 100x^2$

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

$x = 0.411 \text{ m}$

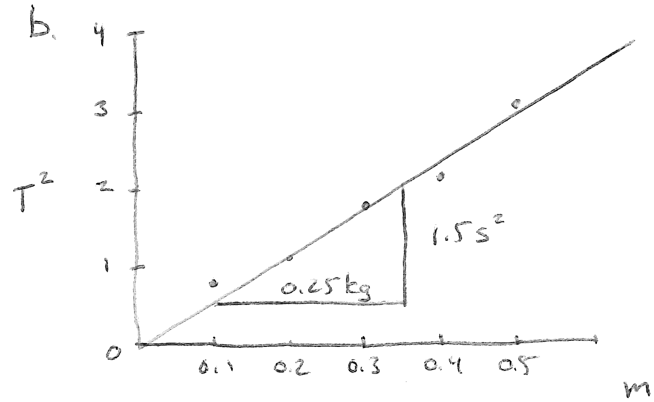
e. $A = 0.411 - 0.098 = 0.313 \text{ m}$

1996 m 1

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

b.



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 MEASURMENTS ARE MADE.

f. $g = \frac{G m_E}{R^2} = \frac{(6.67\times10^{-11}) \cdot (6.0\times10^{24})}{(6.4\times10^6 + 0.3\times10^6)^2}$

$= 8.915 \ m/s^2$

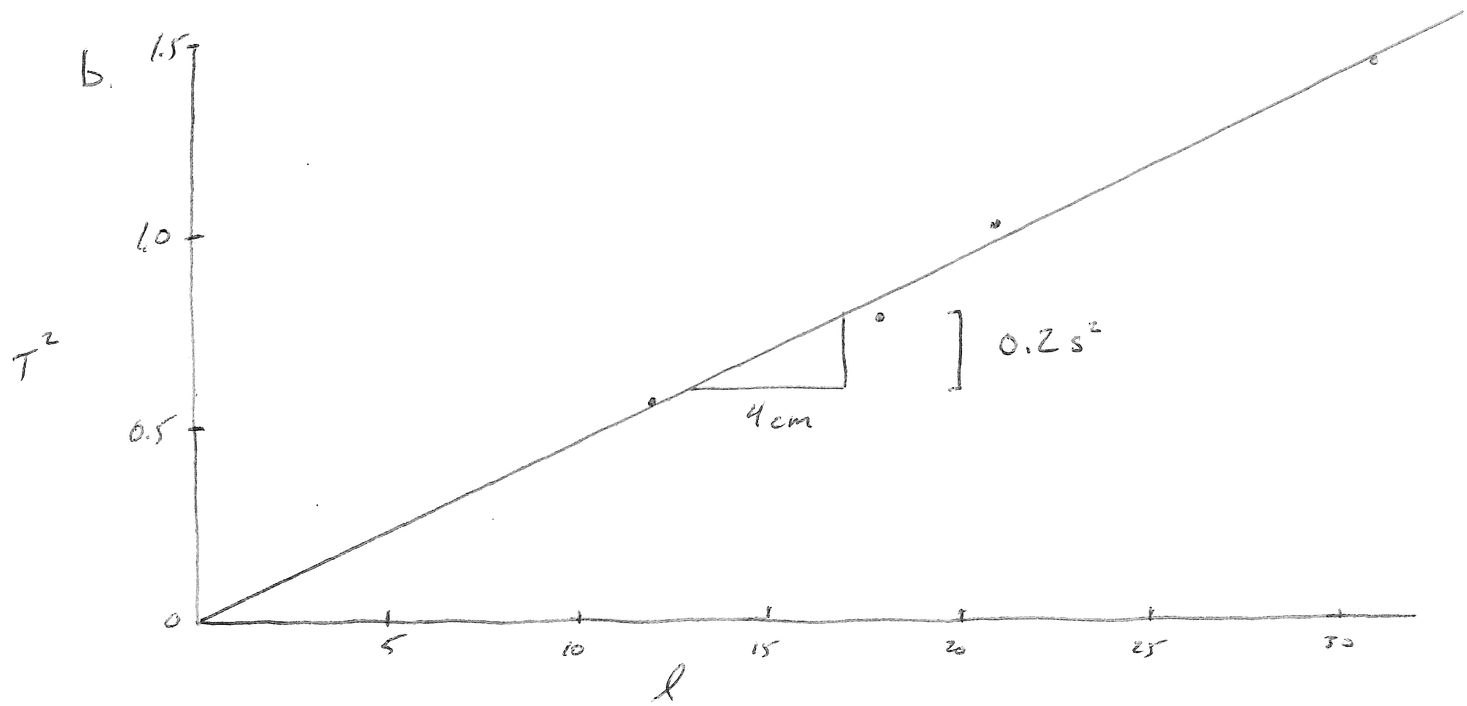
g. THEY ARE IN CONSTANT FREEFALL TOWARDS THE EARTH.

2000 M1

a.

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

b.



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

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

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

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

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

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/s^2 DOWNWARD

2009 M2

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

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

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

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

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

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

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

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

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. $\tau = I\theta$

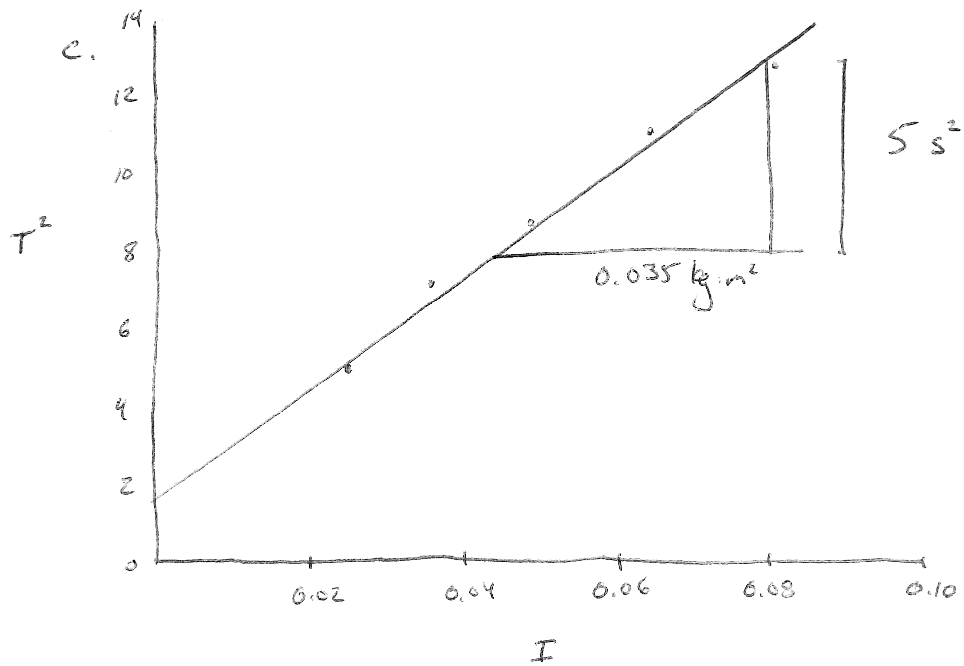
$$-B\theta = I \cdot \frac{d^2\theta}{dt^2}$$

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

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

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

c.



d. $y = mx + b$

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

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

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

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

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

f. IT IS THE PERIOD-SQUARED 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. $x = \int -0.16 \sin(9t)\, dt$

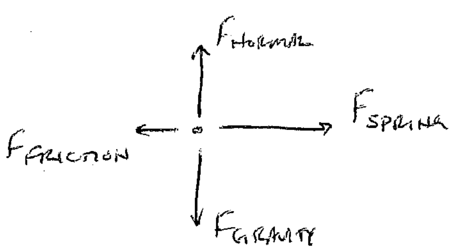
$= 0.018 \cos(9t)$

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

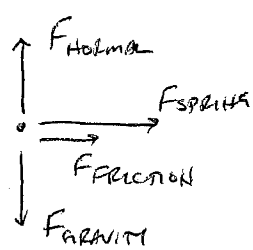
$9 = \sqrt{\frac{k}{0.3}}$

$k = 24.3 \ N/m$

d. TOWARD



AWAY FROM



e.