2009 AllM $\frac{30}{35}$ B

1) $v_f = v_0 + at = 4 \cdot 5 = 20$ (c) ✓

2) $\Delta x = \cancel{v_0 t} + \frac{1}{2}at^2 = \frac{1}{2}(4)(25)$
$= 50m$ (e) ✓

3) (e) ✓ 4) $\Sigma F_1 = m_1 a_1$
$= m_2 a_2$ (c) ✓

5) (b) ✓ 6) $v_f^2 = v_0^2 + 2gd$
$v_f = \sqrt{2(10)(0.2)} = 2$ (b) ✓

7) $\Delta P = 0 = Ft = 1kg \cdot 6 m/s$
s

$F = \frac{dP}{dt} = 6N$ (b) ✓

8) $\Delta\theta = \cancel{\omega_0 t} + \frac{1}{2}\alpha t^2$
$= \frac{1}{2}(3)(4)^2 = 3 \cdot 8 = 24$ (d) ✓

9) $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{2kg}{50 N/m}}$
$= 1.26 = 0.4\pi$ (c) ✓

10) U_{min} (e) ✓

11) $F = \frac{Gmm}{r^2}$ I, III (e) ✓

12) I, II (c) ✓

13) (c) e

14) $N = mg\cos\theta$
$\Sigma F = ma = mg\sin\theta$
(d) ✓

15) $\left(\frac{v}{2}\right)^2 = \frac{1}{4}v^2$ (d) ✓

16) $\frac{dy}{dx} = \frac{B}{A}$ (c) ✓

17) $\frac{dy}{dx} = \frac{2Bt}{A}$ $\frac{dy}{dx} = \frac{2Bt}{2At}$

$\frac{dy}{dx} = \frac{-2A\omega\sin\omega t}{A\omega\sin\omega t}$ $\frac{dy}{dx} = \frac{A\omega\cos\omega t}{-A\omega\sin\omega t}$ (a) e

-3

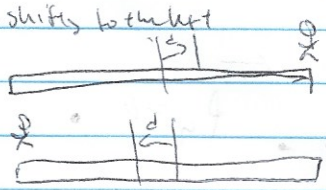
18) circular (a) ✓

19) $mg\sin\theta - \mu mg\cos\theta = 0$
$\mu = \tan\theta$ (e) ✓

20) $F\vec{v}\cos\theta = F\vec{v} = ma\vec{v} = P$
$= (2000kg)(3 m/s^2)\left(\frac{20 - 0 m/s}{2}\right)$
$= 60,000 W$ (e) ✓

21) $x_{cm} = \frac{ML/2}{M + m_p}$

Cm shifts to the left



2d (c) ✓

22) $\Sigma F = ma = mg - kv = m\frac{dv}{dt}$

$\frac{m}{dt} = \frac{mg - kv}{dv}$

$\int_0^t \frac{dt}{m} = \int_0^v \frac{dv}{mg - kv}$ (a) ✓

23) $\Sigma F = Mg - T = 0$ (e) ✓

24) $\Sigma F_{hand} = T = Ma$
$a = \frac{T}{M}$ (d) b

25) L conserved b, c, e $\frac{1}{2}I\omega^2$
RKE is conserved (b) c

26) $m_1 v_1 = m_2 v_2$ $\frac{1}{2}m v_1^2 \neq \frac{1}{2}m_2 v_2^2$
(e) ✓

-2

27) $mv_f = Ft$ $\quad J = F\Delta t = \Delta p$

$v_f = \frac{Ft}{m} = \frac{0.5 \cdot 4}{5\,kg} = \frac{2}{5} = 0.4\,m/s$

$mv_f = \int_0^4 0.5\,t\,dt$

$= \frac{1}{2}\left(\frac{1}{2}t^2\right)\Big|_0^4$

$= \frac{1}{2}\left(\frac{1}{2}16\right) = 4$

$v_f = \frac{4}{5}$ (b)

28) $p_x = mv \leftarrow$

$p_y = 0$

4, b, 4, ...

(d)

29) $v_{oy} = v_0 \sin\theta$

$v_f = v_0 + gt$

$t_{up} = \frac{-v_0 \sin\theta}{-g} = \frac{v_0 \sin\theta}{g}$

(e)

30) $F_T = \frac{mv^2}{r}$ $\quad \frac{mv^2}{2r} \cdot \frac{1}{4} = \frac{1}{8}$

$a = \frac{v^2}{r}$ $\quad v = \frac{2\pi r}{T}$ $\quad$ (e)

$T = \frac{2\pi r}{T}$

$f = \frac{T}{2\pi r}$ $\quad 4T$

31) $mgh = \frac{1}{2}mv_1^2$

$v_1 = \sqrt{2gh}$

$\frac{1}{2}m \cdot 2gh + mgh = \frac{1}{2}mv_2^2$

$2gh = \frac{1}{2}v_2^2$

$v_2^2 = 2(2gh)$

$v_2 = \sqrt{2}\cdot\sqrt{2gh}$ (c)

32) $p_y = 0$ $\quad p_x = 0$ $\quad$ (e)

33) $L = rmv$ $\quad F = \frac{mv^2}{r} = \frac{GMm}{r^2}$

L_1

$v = \sqrt{\frac{GM}{r}}$

v_3 less

$v_2 = \frac{1}{\sqrt{2}}v_0$

(a)

$v_3 = \frac{1}{\sqrt{3}}v_0$

34) (d) $\quad$ 35) $\uparrow F_f$ $\quad \rightarrow \vec{N} = F_c$ $\quad \downarrow mg$

$v = r\omega$

$\mu \frac{mv^2}{R} = mg$

$\mu m \frac{R^2\omega^2}{R} = mg$

$\mu = \frac{g}{r\omega^2}$ (b)

B 32

2009 EK M

9:36 – 9:44
1:32 – 2:09

1) a) at $x = -0.50\,m$,

$E = U + KE$ +1

$= 4.0(-0.50\,m)^2 + \frac{1}{2} m v^2$

$= 4.0(-0.50\,m)^2 + \frac{1}{2}(3.0\,kg)(2.0\,m/s)^2$

$= 1 + 6\,J = \boxed{7.0\,J}$ +1

b) when $KE = 0$, $U = 7.0\,J$ +1

$4.0x^2 = 7.0$ +1

$x^2 = \frac{7.0}{4.0}$

$x = \pm \frac{\sqrt{7}}{2}\,m$

$= \boxed{1.32\,m,\ -1.32\,m}$ +1

c) at $x = 0.60\,m$, $U = 4.0(0.60\,m)^2$

$= 1.44\,J$

+1

$KE = \frac{1}{2}mv^2 = 7 - 1.44\,J = 5.56\,J$

+1 $v = \sqrt{\frac{2\,KE}{m}} = \sqrt{\frac{2(5.56\,J)}{3.0\,kg}}$

calc. error

$= 1.26\,m/s$ 1.92

$p = mv = (3.0\,kg)(1.26\,m/s) = \boxed{3.78\,kg \cdot m/s}$

+1

5.8 kg·m/s

d) $\Sigma F = \frac{dp}{dt} = ma$

$a = \frac{dp}{dt} \cdot \frac{1}{m}$

$p = mv = \sqrt{2mKE} = \sqrt{2m(7 - 4.0x^2)}$

$a = \frac{dp}{dt}\frac{1}{m} = \frac{d}{dt}\frac{1}{m}(\cancel{\sqrt{14m - 8mx^2}})$

$= \frac{1}{m}\frac{d}{dt}(\sqrt{14 - 8x^2})$

d) $p = \sqrt{2m}\sqrt{7 - 4.0x^2}$

$\Sigma F = \frac{dp}{dt} = ma$

$a = \frac{1}{m}\frac{dp}{dt} = \frac{1}{m}\frac{dp}{dx}\cdot\frac{dx}{dt}$

$= \frac{v}{m}\frac{dp}{dx}$

$= \frac{v}{m}\sqrt{2m}\,\frac{d}{dx}(\sqrt{7 - 4.0x^2})$

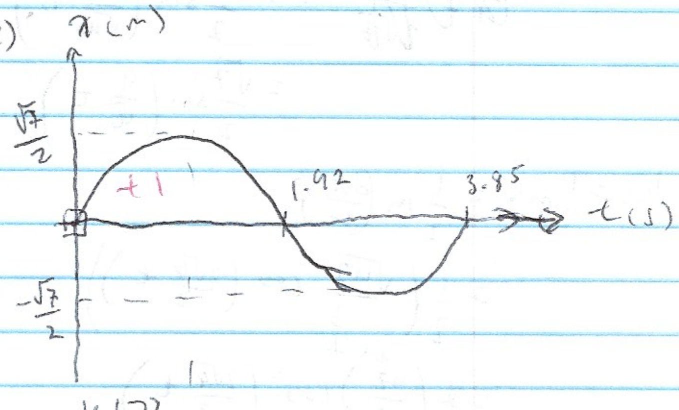
$= \frac{v\sqrt{2}}{\sqrt{m}} \cdot \frac{-4x}{\sqrt{7 - 4.0x^2}}$

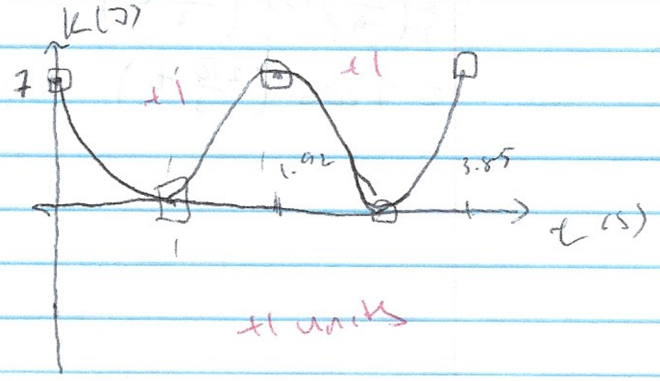
at $x = 0.60\,m$, $v = 1.26\,m/s$

$a = \frac{(1.26\,m/s)\sqrt{2}}{\sqrt{(3.0\,kg)}} \cdot \frac{-4(0.60\,m)}{\sqrt{7 - 4.0(0.60\,m)^2}}$

$|a| = \boxed{1.05\,m/s^2}$ -3

e)





+1 units

$K = 7 - U = 7 - 4x^2$ K vs x -3

e) $KE = \frac{1}{2}mv^2 = 7 - U \quad = 7 - 4x^2$

$$7 - 4x^2 = \frac{1}{2}m\left(\frac{dx}{dt}\right)^2 = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{14-8x^2}{m}} = \frac{dx}{dt}$$

$$dt = \frac{dx}{\sqrt{\frac{14-8x^2}{m}}} = \frac{\sqrt{m}\,dx}{\sqrt{14-8x^2}}$$

$$\int_0^t dt = \sqrt{m}\int_0^x \frac{dx}{\sqrt{14-8x^2}}$$

$$t = \frac{\sqrt{2m}}{4}\arcsin\left(\frac{2\sqrt{7}}{7}x\right)$$

$$\arcsin\left(\frac{2\sqrt{7}}{7}x\right) = \frac{4t}{\sqrt{2m}}$$

$$\frac{2\sqrt{7}}{7}x = \sin\left(\frac{4t}{\sqrt{2m}}\right)$$

$$x = \frac{\sqrt{7}}{2}\sin\left(\frac{4}{\sqrt{2m}}t\right)$$

$$= \frac{\sqrt{7}}{2}\sin\left(\frac{4}{\sqrt{6}}t\right)$$

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{dx}{dt}\right)^2$$

$$= \frac{3}{2}\left(\frac{\sqrt{42}}{3}\cos\left(\frac{2\sqrt{6}}{3}t\right)\right)^2$$

+1 7

$$= \frac{3}{2}\left(\frac{42}{9}\right)\cos^2\left(\frac{2\sqrt{6}}{3}t\right)$$

$$= 7\cos^2\left(\frac{2\sqrt{6}}{3}t\right)$$

2) a)

+1 +1

$$\sum \tau = I_b\alpha = I_b\frac{d^2\theta}{dt^2} = Mgx\sin\theta$$

(i) $$\boxed{\frac{d^2\theta}{dt^2} = \frac{Mgx}{I_b}\sin\theta}$$ +1

(-1) negative torque

$\sin\theta = \theta$ +1

(ii) $$\frac{d^2\theta}{dt^2} \approx \frac{Mgx\theta}{I_b}$$

$\theta = k\sin(\omega t)$

$$\theta = \iint \frac{Mgx\sin\omega t}{I_b}\,dt$$

-2 work

$$T = 2\pi\sqrt{\frac{I_b}{Mgd}}$$ physical pendulums

$$= \boxed{2\pi\sqrt{\frac{I_b}{mgx}}}$$ +1

+1

(b) Set the bar into oscillation at a small amplitude and measure the period with a stopwatch. +1 +1 Use the equation to calculate the I_b. Minimize error by performing multiple trials. +1

(-1) how to find I_b

c) take a thin rail that's elevated off the surface of the lab table. place the bar on the rail and move it until it sits level on the rail, then measure x with a meterstick. Alternatively, have a student balance the bar on their finger.

+2

-4

3) a) ~~ma~~ $\sum F_{sys} = (M)a = \frac{M}{2}g$ +1

$a = \frac{1}{2}g$ +1

~~$v_h - v_0$~~ $= \frac{1}{2}gt$

$v_h^2 = \cancel{v_0^2} + 2ad$ +1

$v_h = \sqrt{2(\frac{1}{2}g)d}$

$\boxed{v_h = \sqrt{gd}}$ +1

b)  $\lambda = \frac{M}{L}$

$m_y = \lambda y = \frac{M}{L}y$

$\boxed{F_g = \frac{M}{L}yg}$ +2

c) $W = \int F \cdot dy = \int_0^y \frac{M}{L}gy\,dy$ +1 +1

$= \frac{M}{L}g\left(\frac{1}{2}y^2\right)_0^y$

$\boxed{W = \frac{Mg}{2L}y^2}$ +1

d) v_y −3

e) v_r greater

b/c the force of gravity changed over time when the force on the block was constant.

−3

−6 ______ tchen

d) ~~$F_g + \frac{M}{L}yg = \left(\frac{M}{L}y\right)a$~~

$W_g = \frac{Mg}{2L}y^2$

$E_{total} = M \cdot g \cdot \frac{L}{2} = PE_g + KE$

$W_g = -\Delta PE$

$KE = E_{total} - W_g$

$= \frac{1}{2}MgL - \frac{Mg}{2L}y^2 = \frac{1}{2}mv_r^2$

$= \frac{1}{2}\left(\frac{M}{L}\cdot y\right)v_r^2$

$v_r^2\left(\frac{My}{\cancel{2}L}\right) = \frac{MgL}{\cancel{2}} - \frac{Mgy^2}{\cancel{2}L}$

$v_r^2 = \frac{MgL^2 - Mgy^2}{My}$

$\boxed{v_r = \sqrt{\frac{g}{y}(L^2 - y^2)}}$ +0

2009 M BR

MC BL 3 R 2

FRB 11 R 2

MC) 5, 13, 17, 24, 25

5) (c) +1

13) (e)? +1

17) (d)? e

24) $\Sigma F = T = Ma$

$a = \frac{T}{M}$ (d) b

25) L conserved (c) +1

17) e 24) b

FR 1) d) $U = 4.0x^2$

$F = \frac{dU}{dx} = 8.0x = ma$ +1 +1

$a = \frac{F}{m} = \frac{8.0x}{m} = \frac{8.0(0.60\,m)}{3.0\,kg}$

$= \boxed{1.6\,m/s^2}$ +1

2) a) (i) $\tau = -Mgx\sin\theta$ +1

(ii) $I_b\frac{d^2\theta}{dt^2} = -Mgx\sin\theta$

$\sin\theta \approx \theta$

$I_b\frac{d^2\theta}{dt^2} + Mgx\,\theta = 0$? +0

2) b) measure T

$T = 2\pi\sqrt{\frac{I_b}{Mgx}}$

$\frac{T}{2\pi} = \sqrt{\frac{I_b}{Mgx}}$

$I_b = \left(\frac{T}{2\pi}\right)^2 Mgx$ +1

+5

3) (d) $W = \Delta KE = \frac{1}{2}mv^2 = \frac{Mg}{2L}y^2$ +1

$\cancel{M}v^2 = \frac{\cancel{M}gy^2}{L}$ +1

$\boxed{v = \sqrt{\frac{gy^2}{L}}}$ +1

(e) v_f is the same, since both systems start with the same mechanical energy, so their final kinetic energies should be the same, which makes the speed the same since the masses are the same. +3

+6

2) a) (ii) $\frac{d^2\theta}{dt^2} + \left(\frac{Mgx}{I_b}\right)\theta = 0$

$\omega^2 = \frac{Mgx}{I_b}$ +2

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

+2