10.4 

$\theta = 2 + 4t^2 + 2t^3$

Then $\omega = \frac{d\theta}{dt} = 8t + 6t^2$

$\alpha = \frac{d\omega}{dt} = 8 + 12t$

a) θ at $t=0$

$\theta = 2 + 4\cdot 0^2 + 2\cdot 0^3 = 2 \text{ rad}$

b) ω at $t=0$

$\omega = 8\cdot 0 + 6 0^2 = 0 \text{ rad/s}$

c) ω at $t=4$

$\omega = 8\cdot 4 + 6\cdot 4^2 = 128 \text{ rad/s}$

d) α at $t=2$ $\alpha = 8 + 12\cdot 2 = 32 \text{ rad/s}^2$

e) Is α = constant? Duh no. It has time dependance $\alpha = 8 + 12t$

10.8  $\alpha = 6t^4 - 4t^2$

At $t=0$ $\omega = +2$ rad/s and $\theta = +1.0$ rad

Get $\omega(t)$:

$\omega = \int \alpha\, dt = \int (6t^4 - 4t^2)\, dt$

$= \frac{6}{5}t^5 - \frac{4}{3}t^3 + \text{const}$

then $2 = \frac{6}{5}(0)^5 - \frac{4}{3}(0)^3 + \text{const}$

$\rightarrow \text{const} = 2$

so that $\omega(t) = \frac{6}{5}t^5 - \frac{4}{3}t^3 + 2$

Get $\theta(t)$:

$\theta = \int \omega\, dt = \int \left(\frac{6}{5}t^5 - \frac{4}{3}t^3 + 2\right) dt$

$= \frac{6}{5\cdot 6}t^6 - \frac{4}{3\cdot 4}t^4 + 2t + \text{const}$

then $1 = \frac{6}{5\cdot 6}0^6 - \frac{4}{3\cdot 4}\cdot 0^4 + 2\cdot 0 + \text{const}$

$\rightarrow \text{const} = 1$

so that $\theta(t) = \frac{6}{30}t^6 - \frac{4}{12}t^4 + 2t + 1$

10.10  $\omega_0 = 0$ const ang accel

In 5 sec, rotated 25 rad

$\theta(t) = \cancel{\theta_0} + \cancel{\omega_0} t + \frac{1}{2}\alpha t^2$ (0, 0)

$\theta = \frac{1}{2}\alpha t^2$

a) Ang Accel $\theta = \frac{1}{2}\alpha t^2$

$25 = \frac{1}{2}\alpha\, 5^2$

$\alpha = 2 \text{ rad/s}^2$

b) Ave ang velocity $\omega_{AVE} = \frac{\Delta\theta}{\Delta t} = \frac{25 \text{ rad}}{5 \text{ sec}} = 5 \text{ rad/s}$

c) Ang velocity at 5 sec

$\theta = \frac{1}{2}\alpha t^2$

$\omega = \frac{d\theta}{dt} = \alpha t = 2(5) = 10 \text{ rad/sec}$

or $\omega(t) = \cancel{\omega_0} + \alpha t = \alpha t = 2(5) = 10 \text{ rad/s}$ (0)

d) What additional angle btw $t = 5 - 10$ sec

at 10 sec $\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 \rightarrow \frac{1}{2}\alpha t^2$

$\frac{1}{2}\, 2\, 10^2 = 100 \text{ rad}$

at 5 sec $\theta = 25$

So $\Delta\theta = 100 - 25 = 75 \text{ rad}$

10.11  $\omega_0 = 120$ rad/s

$\alpha = -4 \text{ rad/s}^2$

$\omega(t) = \omega_0 + \alpha t$ $\quad$ $\theta(t) = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

$\theta_0 = 0$

$\omega_0 = 120$

$\alpha = -4$

$\omega(t) = 120 - 4t$ $\quad$ $\theta(t) = 120t + \frac{1}{2}(-4)t^2$

a) stops when $\omega = 0$

$0 = 120 - 4t$

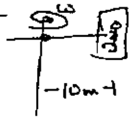
$t = 30 \text{ sec}$

b) Angle

$\theta = 120(30) + \frac{1}{2}(-4)(30)^2$

$= 1800 \text{ rad}$

10.22



$\theta = 0.3t^2$

When $t=5$:

a) Ang velocity $\omega = \frac{d\theta}{dt} = 0.6t$
$= 0.6(5) = 3$ rad/s

b) Linear velocity
$v = R\omega = (10)(3) = 30$ m/s

c) Tangential accel
$\alpha = \frac{d\omega}{dt} = 0.6$ rad/s
so that
$a_{tangential} = R\alpha = 10(0.6) = 6$ m/s^2

d) Radial Accel
$a_{rad} = \frac{v^2}{R} = \frac{(30)^2}{10} = 90$ m/s^2

10.28

$r_A = 10$ cm $\quad r_C = 25$ cm

Angular speed of A increases at $\alpha = 1.6$ rad/s^2
Starts from rest.

The angular speed of pulley A is
$\omega_A(t) = \cancel{\omega_{0A}} + \alpha_A t$
$= 1.6t$

The linear speed of the belt is
$V_{belt} = R_A \omega_A = (10\text{cm})[1.6t]$
$= 16t$

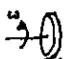
The angular speed of pulley C is
$\omega_C = \frac{V_{belt}}{R_c} = \frac{16t}{25}$

How long does it take for pulley C to reach $100\frac{rev}{min} = 100\frac{2\pi \text{ rad}}{60 \text{ sec}}$
$= 10.47$ rad/s

then
$\omega_c = 10.47 = \frac{16t}{25}$

$\rightarrow t = 16.4$ sec

10.39 Stored energy in a flywheel



top speed 200π rad/s

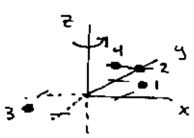
solid
M = 500kg
R = 1 m

a) Max KE in flywheel.
rot KE $= \frac{1}{2} I\omega^2$
disk $I = \frac{1}{2}MR^2 = \frac{1}{2}500(1)^2$
$= 250$ kgm^2

rot KE $= \frac{1}{2}\, 250\, (200\pi)^2 = 49.3$ MegaJoules

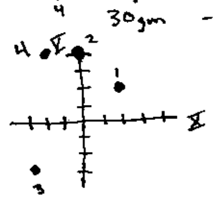
b) Suppose uses energy at 8kW, how long can it operate?
Power $= \frac{\text{Energy}}{\text{time}}$
$8\times10^3 = \frac{49.3\times10^6}{\text{time}}$

time $= 6168$ sec
$= 103$ min



10.42

				distance to xy origin
1	50gm	x = 2 cm	y = 2 cm	$2\sqrt{2}$
2	25gm	0	4	4
3	25gm	−3	−3	$3\sqrt{2}$
4	30gm	−2	4	$\sqrt{20}$



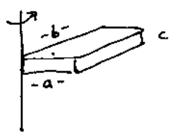
a) Spin about the x-axis. in the formula $I = \Sigma m r_i^2$ – the "r_i" is |y-distance|
$I_x = m_1r_1^2 + m_2r_2^2 + m_3r_3^2 + m_4r_4^2$
$= 50(2)^2 + 25(4)^2 + 25(3)^2 + 30(4)^2$
$= 1305$ g·cm^2

b) Spin about the y-axis. in the formula $I = \Sigma m_i r_i^2$ – the "r_i" is |x-dist|
$I_y = m_1r_1^2 + m_2r_2^2 + m_3r_3^2 + m_4r_4^2$
$= 50(2)^2 + 25(0)^2 + 25(3)^2 + 30(2)^2$
$= 545$ gcm^2

c) Spin about the z axis in the formula $I = \Sigma m r_i^2$ – the "r_i" is distance to origin
$I_z = m_1r_1^2 + m_2r_2^2 + m_3r_3^2 + m_4r_4^2$
$= 50(2\sqrt{2})^2 + 25(4)^2 + 25(3\sqrt{2})^2 + 30(\sqrt{20})^2$
$= 1850$ g·cm^2

d) $I_x + I_y = I_z$

10.43



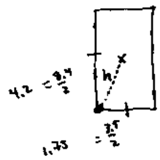
$M = 0.172$ kg
$a = 3.5$ cm
$b = 8.4$ cm
$c = 1.4$ cm

Table 10-2 gives moment of inertia of rectangular slab through center

$$I = \frac{1}{12} M(a^2+b^2)$$
$$= \frac{1}{12}\, 0.172\,(3.5^2 + 8.4^2)$$
$$= 1.187 \ g\cdot cm^2$$

Use the parallel axis theorem to shift the moment of inertia from cm to the corner

$$I = I_{cm} + M h^2$$



$h^2 = (1.75)^2 + (4.2)^2$
$h = 4.55$ cm

$$I = 1.187 + 0.172(4.55)^2$$
$$I = 4.75 \ g\cdot cm^2$$

10.4

$\theta = 2 + 4t^2 + 2t^3$

Then $\omega = \frac{d\theta}{dt} = 8t + 6t^2$

$\alpha = \frac{d\omega}{dt} = 8 + 12t$

a) θ at $t = 0$

$\theta = 2 + 4\cdot 0^2 + 2\cdot 0^3 = 2$ rad

b) ω at $t = 0$

$\omega = 8\cdot 0 + 6 0^2 = 0$ rad/s

c) ω at $t = 4$

$\omega = 8\cdot 4 + 6\cdot 4^2 = 128$ rad/s

d) α at $t = 2$

$\alpha = 8 + 12\cdot 2 = 32$ rad/s^2

e) Is α = constant? Duh no. It has time dependance $\alpha = 8 + 12t$

10.8

$\alpha = 6t^4 - 4t^2$

At $t = 0$ $\omega = +2$ rad/s and $\theta = +1.0$ rad

Get $\omega(t)$:

$\omega = \int \alpha\, dt = \int (6t^4 - 4t^2)\, dt$

$= \frac{6}{5}t^5 - \frac{4}{3}t^3 + \text{const}$

then $2 = \frac{6}{5}(0)^5 - \frac{4}{3}(0)^3 + \text{const}$

$\rightarrow$ const = 2

so that

$\omega(t) = \frac{6}{5}t^5 - \frac{4}{3}t^3 + 2$

Get $\theta(t)$:

$\theta = \int \omega\, dt = \int \left(\frac{6}{5}t^5 - \frac{4}{3}t^3 + 2 \right) dt$

$= \frac{6}{5\cdot 6}t^6 - \frac{4}{3\cdot 4}t^4 + 2t + \text{const}$

then $1 = \frac{6}{5\cdot 6}0^6 - \frac{4}{3\cdot 4}\cdot 0^4 + 2\cdot 0 + \text{const}$

$\rightarrow$ const = 1

so that

$\theta(t) = \frac{6}{30}t^6 - \frac{4}{12}t^4 + 2t + 1$

10.10 

$\omega_0 = 0$
const ang accel
In 5 sec, rotated 25 rad

$\theta(t) = \cancel{\theta_0}^{\,0} + \cancel{\omega_0}^{\,0} t + \frac{1}{2}\alpha t^2$

$\theta = \frac{1}{2}\alpha t^2$

a) Ang Accel $\quad \theta = \frac{1}{2}\alpha t^2$

$25 = \frac{1}{2}\alpha\, 5^2$

$\alpha = 2 \ \text{rad}/s^2$

b) Ave ang velocity

$\omega_{AVE} = \frac{\Delta\theta}{\Delta t} = \frac{25\,\text{rad}}{5\,\text{se}} = 5\ \text{rad}/s$

c) Ang velocity at 5 sec

$\theta = \frac{1}{2}\alpha t^2$

$\omega = \frac{d\theta}{dt} = \alpha t = 2(5) = 10\ \text{rad}/\text{sec}$

or $\quad \omega(t) = \cancel{\omega_0}^{\,0} + \alpha t = \alpha t = 2(5) = 10\ \text{rad}/s$

d) What additional angle btw $t = 5 - 10$ sec

at 10 sec $\quad \theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 \rightarrow \frac{1}{2}\alpha t^2$

$\frac{1}{2}\, 2\ 10^2 = 100$ rad

at 5 sec $\quad \theta = 25$

So $\quad \Delta\theta = 100 - 25 = 75$ rad

10.11 

$\omega_0 = 120\ \text{rad}/s$

$\alpha = -4\ \text{rad}/s^2$

$\omega(t) = \omega_0 + \alpha t \qquad \theta(t) = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

$\theta_0 = 0$
$\omega_0 = 120$
$\alpha = -4$

$\omega(t) = 120 - 4t \qquad \theta(t) = 120t + \frac{1}{2}(-4)t^2$

a) stops when $\omega = 0$

$0 = 120 - 4t$

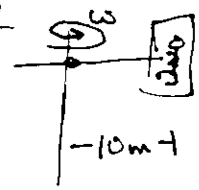
$t = 30$ sec

b) Angle

$\theta = 120(30) + \frac{1}{2}(-4)(30)^2$

$= 1800$ rad

10.22



$\theta = 0.3t^2$

When $t=5$:

a) Ang velocity
$$\omega = \frac{d\theta}{dt} = 0.6t$$
$$= 0.6(5) = 3 \text{ rad/s}$$

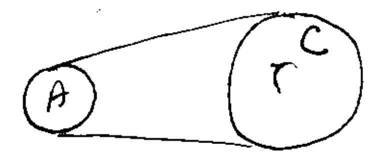
b) Linear velocity
$$V = R\omega = (10)(3) = 30 \text{ m/s}$$

c) Tangential accel
$$\alpha = \frac{d\omega}{dt} = 0.6 \text{ rad/s}$$

so that
$$a_{tangential} = R\alpha = 10(0.6) = 6 \text{ m/s}^2$$

d) Radial Accel
$$a_{rad} = \frac{v^2}{R} = \frac{(30)^2}{10} = 90 \text{ m/s}^2$$

10.28



$r_A = 10\text{ cm}$ $\qquad r_C = 25\text{ cm}$

Angular speed of A increases at $\alpha = 1.6 \text{ rad/s}^2$
Starts from rest.

The angular speed of pulley A is
$$\omega_A(t) = \cancel{\omega_{0A}} + \alpha_A t$$
$$= 1.6t$$

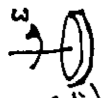
The linear speed of the belt is
$$V_{belt} = R_A \omega_A = (10\text{cm})[1.6t]$$
$$= 16t$$

The angular speed of pulley C is
$$\omega_C = \frac{V_{belt}}{R_C} = \frac{16t}{25}$$

How long does it take for pulley C to reach $100 \frac{\text{rev}}{\text{min}} = 100 \frac{2\pi \text{ rad}}{60 \text{ sec}}$
$$= 10.47 \text{ rad/s}$$

Then
$$\omega_c = 10.47 = \frac{16t}{25}$$
$$\rightarrow t = 16.4 \text{ sec}$$

10.39 Stored energy in a flywheel



top speed 200π rad/s

solid
M = 500 kg
R = 1 m

a) Max KE in flywheel.

$$\text{rot } KE = \tfrac{1}{2} I \omega^2$$

$$\text{disk } I = \tfrac{1}{2} MR^2 = \tfrac{1}{2} 500 (1)^2$$
$$= 250 \text{ kgm}^2$$

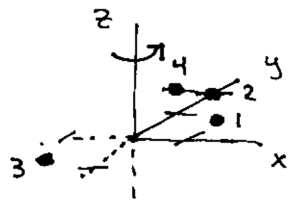
$$\text{rot } KE = \tfrac{1}{2}\, 250\, (200\pi)^2 = 49.3 \text{ MegaJoules}$$

b) suppose uses energy at 8 kW, how long can it operate?

$$\text{Power} = \frac{\text{Energy}}{\text{time}}$$

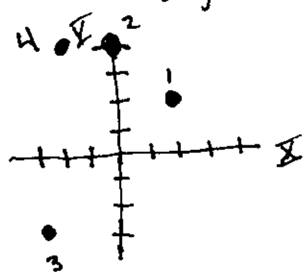
$$8\times10^3 = \frac{49.3\times10^6}{\text{time}}$$

$$\text{time} = 6168 \text{ sec}$$
$$= 103 \text{ min}$$



10.42

				xy distance to origin
1	50 gm	x = 2 cm	y = 2 cm	$2\sqrt{2}$
2	25 gm	0	4	4
3	25 gm	−3	−3	$3\sqrt{2}$
4	30 gm	−2	4	$\sqrt{20}$



a) Spin about the x-axis.
in the formula $I = \sum m_i r_i^2$ – the "r_i" is |y-distance|

$$I_x = m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2 + m_4 r_4^2$$
$$= 50(2)^2 + 25(4)^2 + 25(3)^2 + 30(4)^2$$
$$= 1305 \text{ g}\cdot\text{cm}^2$$

b) Spin about the y-axis.
in the formula $I = \sum m_i r_i^2$ – the "r_i" is |x-dist|

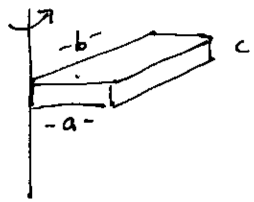
$$I_y = m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2 + m_4 r_4^2$$
$$= 50(2)^2 + 25(0)^2 + 25(3)^2 + 30(2)^2$$
$$= 545 \text{ g cm}^2$$

c) Spin about the z axis
in the formula $I = \sum m_i r_i^2$ – the "r_i" is distance to origin

$$I_z = m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2 + m_4 r_4^2$$
$$= 50(2\sqrt{2})^2 + 25(4)^2 + 25(3\sqrt{2})^2 + 30(\sqrt{20})^2$$
$$= 1850 \text{ g}\cdot\text{cm}^2$$

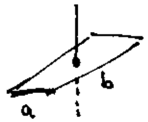
d) $I_x + I_y = I_z$

10.43



$M = 0.172$ kg
$a = 3.5$ cm
$b = 8.4$ cm
$c = 1.4$ cm

Table 10-2 gives moment of inertia of rectangular slab through center



$$I = \frac{1}{12} M(a^2+b^2)$$
$$= \frac{1}{12} 0.172 (3.5^2 + 8.4^2)$$
$$= 1.187 \ g \cdot cm^2$$

Use the parallel axis theorem to shift the moment of ~~inertia~~ from cm to the corner

$$I = I_{cm} + Mh^2$$

$h^2 = (1.75)^2 + (4.2)^2$
$h = 4.55$ cm

$$I = 1.187 + 0.172(4.55)^2$$
$$I = 4.75 \ g \cdot cm^2$$