Your Name: _____

PHY203
Exam #3
Chapters 9-11,15
Mon., 5/1/23

Solutions

Exam3S23

1. A wheel released from rest is rotating with constant angular acceleration of 2.80 rad/s^2. We want to find some properties of the wheel after it has been rotating for 6.50 s.

a. List the known quantities below:

Parameter	Known Value
θ_0	0
θ_f	
ω_0	0
ω_f	
α	2.80 rad/s^2
t	6.50 s

b. Find the angular velocity after the wheel has been rotating for 6.50 s. **10**

$$\omega = 0 + 2.80(6.50)$$
$$= 18.2 \text{ rad/s}$$

c. Find the number of revolutions the wheel has turned through after the wheel has been rotating for 6.50 s. **10**

$$\theta = 0 + 0 + \frac{1}{2}(2.80)(6.50)^2$$
$$= \frac{59.15 \text{ rad}}{2\pi} = 9.41 \text{ rev}$$

d. Find the tangential speed of a point 0.800 m from the axis of rotation after the wheel has been rotating for 6.50 s. **10**

$$v_{tan} = \omega r = (18.2)(0.800)$$
$$= 14.6 \text{ m/s}$$

2. A solid sphere with mass 5.00 kg and radius 1.50 m is rolling without slipping on a horizontal surface. The linear speed of the sphere is 6.50 m/s.

a. List the known quantities below:

Parameter	Known Value
F	
r	1.50 m
m	5.00 kg
v	6.50 m/s

b. Find the moment of inertia of the sphere about its central axis. **5**

$$I = \frac{2}{5}(5.00)(1.50)^2 = 4.50\ \text{kg m}^2$$

c. Find the angular speed of the sphere about an axis through the center of mass. **5**

$$\omega = \frac{v_{cm}}{r} = \frac{6.50}{1.50} = 4.33\ \text{rad/s}$$

d. Find the kinetic energy of the sphere. **10** /5

$$E = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$
$$= \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\frac{v^2}{r^2}$$
$$= \frac{1}{2}mv^2\left(1+\frac{2}{5}\right) = \frac{1}{2}(5.00)(6.50)^2(1.4) = 148\ \text{J}$$

e. An additional kinetic energy of 25.0 J is added to the sphere. Find its new linear speed. **15** /0

$$148 + 25 = 173\ \text{J}$$
$$173 = \frac{1}{2}mv'^2(1.4)$$
$$= \frac{1}{2}(5.00)v'^2(1.4)$$
$$v'^2 = \frac{173}{(2.50)(1.4)},\quad v' = 7.03\ \text{m/s}$$

3. A block of mass 2.50 kg is attached to a spring, stretched by 0.450 m and released at t=0. At a time of 0.330 s, the block is at an x-position of -0.150 m.

a. Identify and list the known quantities (in SI units) (these could include m,A,x,t,v,a,E,T,f,ω, …)

$m = 2.50\,kg,\ A = 0.450\,m,\ t = 0.330\,s,\ x = -0.150\,m$

b. Find the angular frequency of the block-spring combination. **15**

$x = A\cos\omega t$

$-0.150 = 0.450\cos\omega(0.330)$

$\cos(.33\omega) = -0.333$

$.33\omega = 1.91$

$\omega = 5.79\ rad/s$

c. Find the maximum velocity of the block. **10**

$v = -\omega A\sin\omega t$

$v_{max} = \omega A = (5.79)(0.450)$

$= 2.60\,m/s$

d. Find the energy of the block-spring combination. **10**

$k = m\omega^2 = (2.50)(5.79)^2 = 83.8\,N/m$

$E = \frac{1}{2}kA^2 = \frac{1}{2}(83.8)(0.450)^2$

$= 8.49\ J$

Exam3S23alt

1. A wheel released from rest is rotating with constant angular acceleration of 3.80 rad/s^2. We want to find some properties of the wheel after it has been rotating for 6.00 s.

a. List the known quantities below:

Parameter	Known Value
θ_0	0
θ_f	
ω_0	0
ω_f	
α	3.80 rad/s^2
t	6.00 s

b. Find the angular velocity after the wheel has been rotating for 6.00 s. **10**

$$\omega = 0 + 3.80(6.00)$$

$$= 22.8 \text{ rad/s}$$

c. Find the number of revolutions the wheel has turned through after the wheel has been rotating for 6.00 s. **10**

$$\theta = 0 + 0 + \frac{1}{2}(3.80)(6.00)^2$$

$$= \frac{68.4 \text{ rad}}{2\pi} = 10.9 \text{ rev}$$

d. Find the tangential speed of a point 0.800 m from the axis of rotation after the wheel has been rotating for 6.00 s. **10**

$$v_{tan} = \omega r = (22.8)(0.800)$$

$$= 18.2 \text{ m/s}$$

2. A solid sphere with mass 6.00 kg and radius 1.25 m is rolling without slipping on a horizontal surface. The linear speed of the sphere is 8.50 m/s.

a. List the known quantities below:

Parameter	Known Value
F	
r	1.25 m
m	6.00 kg
v	8.50 m/s

b. Find the moment of inertia of the sphere about its central axis. **5**

$$I = \frac{2}{5}(6.00)(1.25)^2 = 3.75 \text{ kg m}^2$$

c. Find the angular speed of the sphere about an axis through the center of mass. **5**

$$\omega = \frac{v_{cm}}{r} = \frac{8.50}{1.25} = 6.80 \text{ rad/s}$$

d. Find the kinetic energy of the sphere. **10** 10/5

$$E = \frac{1}{2}mv^2 + \frac{1}{2}Iv^2 = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\frac{v^2}{r^2}$$

$$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2\left(\frac{2}{5}\right) = \frac{1}{2}mv^2(1.4)$$

$$= \frac{1}{2}(6.00)(8.50)^2(1.4) = 303 \text{ J}$$

e. An additional kinetic energy of 25.0 J is added to the sphere. Find its new linear speed. **15** 10

$$303 + 25 = 328 \text{ J}$$

$$328 \text{ J} = \frac{1}{2}mv'^2(1.4)$$

$$= \frac{1}{2}(6.00)v'^2(1.4)$$

$$v'^2 = \frac{328}{(3.00)(1.4)} \qquad v' = 8.84 \text{ m/s}$$

3. A block of mass 3.50 kg is attached to a spring, stretched by 0.500 m and released at t=0. At a time of 0.430 s, the block is at an x-position of -0.150 m.

a. Identify and list the known quantities (in SI units) (these could include m,A,x,t,v,a,E,T,f,ω, …)

$m = 3.50\ kg,\ A = 0.500\ m,\ t = 0.430\ s,\ x = -.150\ m$

b. Find the angular frequency of the block-spring combination. **15**

$x = A\cos\omega t$

$-.150 = (.500)\cos\omega(.430)$

$\cos(.430\omega) = -.300$

$.430\omega = 1.875$

$\omega = 4.36\ rad/s$

c. Find the maximum velocity of the block. **10**

$v = -\omega A\sin\omega t$

$v_{max} = \omega A$

$= (4.36)(0.500)$

$= 2.18\ m/s$

d. Find the energy of the block-spring combination. **10**

$E = \frac{1}{2}kA^2$ $\qquad \omega = \sqrt{\frac{k}{m}}$

$= \frac{1}{2}(66.5)(.500)^2$ $\qquad k = m\omega^2 = (3.50)(4.36)^2$

$= 66.5\ N/m$

$= 8.32\ J$