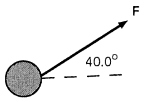
Your Name: _____

PHY203
Exam #3
Chapters 9-11,15
Mon., 12/12/22

Solutions

Exam3F22



1. A wheel consists of a solid disk of radius 0.850 m and mass 3.50 kg. The wheel is pinned through its axis and allowed to rotate freely. The wheel is initially at rest. A force of 15.5 N is applied at an angle of 40.0° as shown. We want to know some properties of the wheel after it has been spinning for 15.0 s.

List the known quantities below:

Parameter	Known Value
F	15.5 N
r	0.850 m
m	3.50 kg
θ	40.0°
t	15.0 s

a. Find the moment of inertia of the wheel about its axis. **5**

$I = \frac{1}{2} MR^2 = \frac{1}{2}(3.50)(0.850)^2 = 1.26\ kg\,m^2$

b. Find the magnitude of the torque on the wheel. **5**

$\tau = rF\sin\theta = (0.850)(15.5)\sin(40^\circ) = 8.47\ Nm$

c. Find the magnitude of the angular acceleration of the wheel. **5**

$\alpha = \frac{\tau}{I} = \frac{8.47}{1.26} = 6.72\ rad/s^2$

d. Find the angular speed after the force has been applied for 15.0 s. **5**

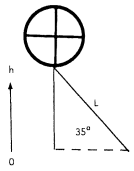
$\omega = \omega_0 + \alpha t = 0 + 6.72(15.0) = 101\ rad/s$

e. Find how many revolutions the wheel has made after 15.0 s. **10**

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

$= 0 + 0 + \frac{1}{2}(6.72)(15.0)^2$

$= \frac{754\ rad}{2\pi} = 120\ rev$

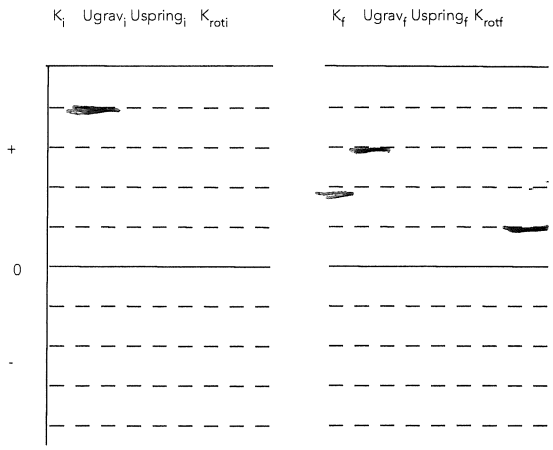


2. A wheel starts from rest at the top of a ramp which makes an angle of 35.0° with respect to the horizontal and has a height of h = 5.00 m. The wheel consists of a thin rim with mass 3.50 kg, radius 1.50 m, and 4 spokes of length 1.50 m and mass 0.450 kg apiece. The wheel is released and starts to roll down the ramp.

List the known quantities below:

Parameter	Known Value
h	5.00 m
r	1.50 m
M	3.50 kg
L	1.50 m
m	0.450 kg

a. Create energy bar charts for the wheel at the top of the ramp and after it has rolled 3.00 m along the ramp: **5**



b. Find the moment of inertia of the wheel. **10**

$$I = MR^2 + 4\left(\frac{1}{3}mL^2\right)$$

$$= R^2\left[m + \frac{4}{3}m\right] = (1.50)^2\left[3.50 + \frac{4}{3}(0.450)\right]$$

$$= 9.22\ kg\,m^2 \qquad 7.88 + 1.35$$

d. Use Conservation of Energy to find the kinetic energy of the wheel once it has rolled 3.00 m along the ramp. (Note: 3.00 m is the distance along the ramp, not the height change.) **15**

$M_{tot} = 3.50\,kg + 4(1.95\,kg) = 5.3\,kg$

$h_{change} = 3.00 \sin(35^\circ) = 1.72\,m$

$M_{tot} g (5.00) = M_{tot}(5 - 1.72) g + KE$

$KE = (5.30)\, g\, (1.72)$

$= 89.5\,J$

e. Find the linear speed of the center of mass of the wheel at this point. **15**

$89.5 = \frac{1}{2} m v^2 + \frac{1}{2} I \omega^2$

$= \frac{1}{2} v^2 \left[M_{tot} + \frac{I}{r^2} \right]$

$= \frac{1}{2} v^2 \left[5.30 + \frac{9.22}{1.50^2} \right]$

$= \frac{1}{2} v^2 (9.40)$

$v = 4.36\,m/s$

3. The position of a particle is given by $x = 4.20 \cos 3.00t$, where x is in meters and t is in seconds.

a. Identify and list the known quantities (in SI units) (these could include m,A,x,t,v,a,E,T,f,ω, …) **5**

$A = 4.20\ m, \quad \omega = 3.00\ rad/s$

b. Find the period of the motion. **5**

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{3} = 2.10\ s$$

c. Find the maximum speed of the particle. **5**

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

$$v_{max} = \omega A = (3.00)(4.20)$$

$$= 12.6\ m/s$$

d. Find the speed of the particle when it is at a position of 1.30 m. **10**

$$x = 1.30 = 4.20 \cos 3.00t$$

$$\cos(3.00t) = \frac{1.30}{4.20} = 0.310$$

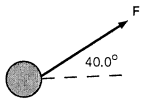
$$3.00t = \cos^{-1}(0.310) = 1.26$$

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

$$= -(3.00)(4.20)\sin(1.26)$$

$$= -12.0\ m/s$$

Exam3F22alt



1. A wheel consists of a solid disk of radius 0.950 m and mass 4.50 kg. The wheel is pinned through its axis and allowed to rotate freely. The wheel is initially at rest. A force of 17.5 N is applied at an angle of 40.0° as shown. We want to know some properties of the wheel after it has been spinning for 15.0 s.

List the known quantities below:

Parameter	Known Value
F	17.5 N
r	0.950 m
m	4.50 kg
θ	40.0°
t	15.0 s

a. Find the moment of inertia of the wheel about its axis. **5**

$I = \frac{1}{2}MR^2 = \frac{1}{2}(4.50)(0.950)^2 = 2.03\ kg\,m^2$

b. Find the magnitude of the torque on the wheel. **5**

$\tau = rF\sin\theta = (0.950)(17.5)\sin(40.0^\circ) = 10.7\ N\,m$

c. Find the magnitude of the angular acceleration of the wheel. **5**

$\alpha = \frac{\tau}{I} = \frac{10.7}{2.03} = 5.26\ rad/s^2$

d. Find the angular speed after the force has been applied for 15.0 s. **5**

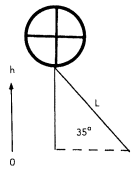
$\omega = \omega_0 + \alpha t = 0 + (5.26)(15.0) = 79.0\ rad/s$

e. Find how many revolutions the wheel has made after 15.0 s. **10**

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

$= 0 + 0 + \frac{1}{2}(5.26)(15.0)^2 = 592\ rad$

$\frac{592}{2\pi} = 94.2\ rev$

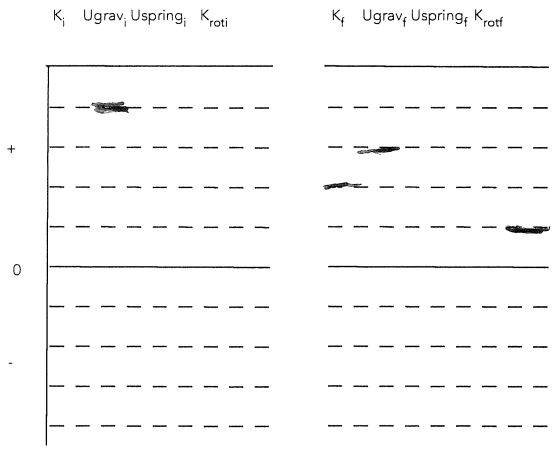


2. A wheel starts from rest at the top of a ramp which makes an angle of 35.0° with respect to the horizontal and has a height of h = 6.00 m. The wheel consists of a thin rim with mass 2.50 kg, radius 1.75 m, and 4 spokes of length 1.75 m and mass 0.450 kg apiece. The wheel is released and starts to roll down the ramp.

List the known quantities below:

Parameter	Known Value
h	6.00m
r	1.75 m
M	2.50 kg
L	1.75 m
m	0.450 kg

a. Create energy bar charts for the wheel at the top of the ramp and after it has rolled 3.00 m along the ramp: **5**



b. Find the moment of inertia of the wheel. **10**

$$I = Mr^2 + 4\left(\frac{1}{3}mL^2\right)$$

$$= r^2\left[2.50 + \frac{4}{3}(4.50)\right]$$

$$= (1.75)^2(3.1) = 9.49\ kgm^2$$

7.66 + 1.84

d. Use Conservation of Energy to find the kinetic energy of the wheel once it has rolled 3.00 m along the ramp. (Note: 3.00 m is the distance along the ramp, not the height change.) **15**

$M_{tot} = 2.50 + 4(0.450) = 4.30\ kg$

$h' = 6.00\ m - 3.00 \sin(35^\circ) = 4.28\ m$

$M_{tot} g (6.00) = M_{tot} g (4.28) + KE$

$KE = M_{tot} g (1.72)$

$= (4.30) g (1.72)$

$= 72.4\ J$

e. Find the linear speed of the center of mass of the wheel at this point. **15**

$72.4 = \frac{1}{2} M_{tot} v^2 + \frac{1}{2} I \omega^2$

$= \frac{1}{2} v^2 \left[M_{tot} + \frac{I}{r^2} \right]$

$= \frac{1}{2} v^2 \left[4.30 + \frac{9.27}{1.25^2} \right]$

$= \frac{1}{2} v^2 (7.20)$

$v = 4.43\ m/s$

3. The position of a particle is given by $x = 5.20 \cos 3.50t$, where x is in meters and t is in seconds.

a. Identify and list the known quantities (in SI units) (these could include m,A,x,t,v,a,E,T,f,ω, …) **5**

$A = 5.20\ m, \quad \omega = 3.50\ rad/s$

b. Find the period of the motion. **5**

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{3.50} = 1.80\ s$$

c. Find the maximum speed of the particle. **5**

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

$$v_{max} = \omega A = (3.50)(5.20)$$

$$= 18.2\ m/s$$

d. Find the speed of the particle when it is at a position of 1.40 m. **10**

$$1.40 = 5.20 \cos 3.50t$$

$$\cos 3.50t = \frac{1.40}{5.20} = 0.269$$

$$3.50t = 1.30$$

$$v = -(3.50)(5.20)\sin(1.30)$$

$$= -17.5\ m/s$$