

Your Name: _____

PHY203

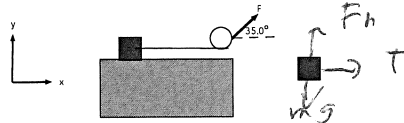
Exam #3

Chapters 9-11,15

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week, Dec 11, 2024

Solutions



1. A block on a frictionless table is attached to a light string wrapped around a pulley. The string is being pulled by a force F at an angle of 35.0° , as shown above. Given m for the block and M and R for the pulley (a solid disk).

a. Draw a free body diagram for the block above and to the right. 5

b. Write out Newton's 2nd Law for the block in all directions and the torque equation for the pulley. 20

$$x: T = ma$$

$$y: F_n - mg = 0$$

$$z: (F \sin 35^\circ - T) R = I \alpha = I \frac{a}{R}$$

Given $m=5.50$ kg, $M=4.00$ kg, $R=0.500$ m, and $F=85.0$ N.

c. Find the magnitude of the acceleration of the block. 10

$$\rightarrow (F \sin 35^\circ - T) R = \frac{1}{2} M R \frac{a}{R}$$

$$\rightarrow T = ma$$

$$F \sin 35^\circ = a \left(m + \frac{M}{2} \right)$$

$$a = \frac{85 \sin 35^\circ}{\left(5.50 + \frac{4.00}{2} \right)} = 6.50 \text{ m/s}^2$$



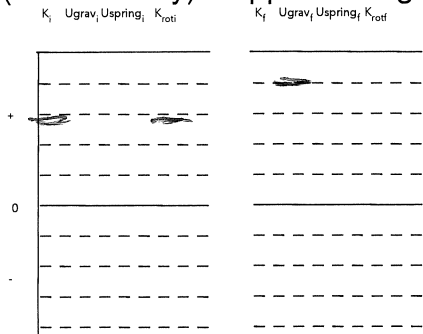
2. A wheel is rolling without slipping on a horizontal surface with a linear speed of 12.5 m/s. It rolls up a rough ramp which makes an angle of 55.0° with respect to the horizontal. The wheel is a thin rim with mass 3.50 kg and radius of 1.50 m.
- a. Find the moment of inertia of the wheel through its axis. **5**

$$I = m r^2 = (3.50)(1.50)^2 = 7.88 \text{ kg m}^2$$

- b. Find the kinetic energy of the wheel as it is rolling on the horizontal surface. **20**

$$\begin{aligned} K &= \frac{1}{2} m v^2 + \frac{1}{2} I \omega^2 \\ &= \frac{1}{2} m v^2 + \frac{1}{2} m r^2 \frac{v^2}{r^2} \\ &= m v^2 = (3.50)(12.5)^2 \\ &= 547 \text{ J} \end{aligned}$$

- c. Create energy bar charts. Take the final position of the wheel after it has (momentarily) stopped rolling-the highest position it reaches. **5**



- c. Use Conservation of Energy to find the maximum height of the wheel. **5**

$$\begin{aligned} 547 &= m g h \\ &= 3.5 g h \\ h &= \frac{547}{3.5 g} = 15.9 \text{ m} \end{aligned}$$

3. A block of mass 2.50 kg is attached to a spring, stretched by 0.450 m and released at $t=0$. The period of the motion is 0.300 s.

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

$$m = 2.50 \text{ kg}, \quad A = 0.450 \text{ m}, \quad T = 0.300 \text{ s}$$

b. Find the energy of the block-spring combination. 15

$$\omega = \sqrt{\frac{k}{m}} \neq \frac{2\pi}{T}, \quad \omega = \frac{2\pi}{0.300} = 20.9 \text{ rad/s}$$

$$k = m\omega^2 = (2.50)(20.9)^2 = 1.10 \times 10^3 \frac{\text{N}}{\text{m}}$$

$$E = \frac{1}{2}kA^2 = \frac{1}{2}(1.10 \times 10^3)(0.450)^2 \\ = 111 \text{ J}$$

c. Find the acceleration when the velocity is ± 6.00 m/s. 15

$$x = A \cos \omega t$$

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

$$6.00 = -(0.450)(20.9) \sin \omega t$$

$$\sin \omega t = +0.637$$

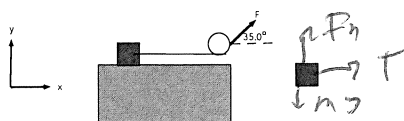
$$\omega t = +0.691 \quad \text{or} \quad t = 0.0330 \text{ s}$$

$$a = -A\omega^2 \cos \omega t$$

$$= -(0.450)(20.9)^2 \cos(0.691)$$

$$= -151 \text{ m/s}^2$$

PHY203ExamF24Alt



1. A block on a frictionless table is attached to a light string wrapped around a pulley. The string is being pulled by a force F at an angle of 35.0° , as shown above. Given m for the block and M and R for the pulley (a solid disk).

a. Draw a free body diagram for the block above and to the right. 5

b. Write out Newton's 2nd Law for the block in all directions and the torque equation for the pulley. 20

$$x: T = ma$$

$$y: F_n - mg = 0$$

$$z: (F \sin 35.0^\circ - T) R = I \alpha = \pm \frac{a}{R}$$

Given $m=6.50$ kg, $M=3.00$ kg, $R=0.500$ m, and $F=95.0$ N.

c. Find the magnitude of the acceleration of the block. 10

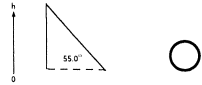
$$T = ma$$

$$(F \sin 35.0^\circ - T) R = \frac{1}{2} M R^2 \frac{a}{R}$$

$$F \sin 35.0^\circ = a \left(m + \frac{1}{2} M \right)$$

$$a = \frac{(95.0) \sin 35.0^\circ}{6.50 + \frac{1}{2} (3.00)}$$

$$= 6.81 \text{ m/s}^2$$



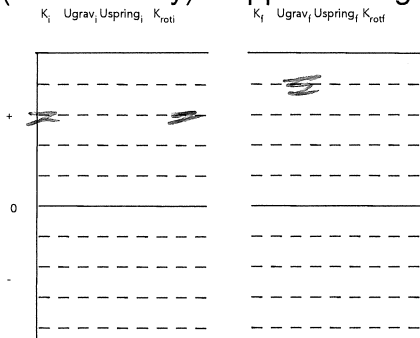
2. A wheel is rolling without slipping on a horizontal surface with a linear speed of 14.5 m/s. It rolls up a rough ramp which makes an angle of 55.0° with respect to the horizontal. The wheel is a thin rim with mass 4.50 kg and radius of 1.25 m.
- a. Find the moment of inertia of the wheel through its axis. **5**

$$I = m r^2 = 4.50 (1.25)^2 = 7.03 \text{ kg m}^2$$

- b. Find the kinetic energy of the wheel as it is rolling on the horizontal surface. **20**

$$\begin{aligned}
 K &= \frac{1}{2} m v^2 + \frac{1}{2} I \omega^2 = \frac{1}{2} m v^2 + \frac{1}{2} (m r^2) \frac{v^2}{r^2} \\
 &= m v^2 \\
 &= (4.50) (14.5)^2 = 946.5
 \end{aligned}$$

- c. Create energy bar charts. Take the final position of the wheel after it has (momentarily) stopped rolling-the highest position it reaches. **5**



- c. Use Conservation of Energy to find the maximum height of the wheel. **5**

$$\begin{aligned}
 946 &= m g h \\
 &= (4.50) g h \\
 h &= 21.8 \text{ m}
 \end{aligned}$$

3. A block of mass 3.50 kg is attached to a spring, stretched by 0.650 m and released at $t=0$. The period of the motion is 0.400 s.

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

$$m = 3.50 \text{ kg}, T = 0.400 \text{ s}, A = 0.650 \text{ m}$$

b. Find the energy of the block-spring combination. 15

$$E = \frac{1}{2} k A^2$$

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{0.400} = 15.7$$

$$k = m \omega^2 = (3.50)(15.7)^2 = 8644 \text{ N/m}$$

$$E = \frac{1}{2} (8644)(0.650)^2 = 182 \text{ J}$$

c. Find the acceleration when the velocity is -6.00 m/s. 15

$$v = -\omega A \sin \omega t = -6.00$$

$$6.00 = (15.7)(0.650) \sin 15.7 t$$

$$\sin 15.7 t = 0.589$$

$$15.7 t = 0.629$$

$$t = 0.0400$$

$$a = -\omega^2 A \cos \omega t$$

$$= -15.7^2 (0.650) \cos (0.629)$$

$$= -130 \text{ m/s}^2$$