Physics 201 MWF9:10 Fall 2009 (Ford)

Name (printed) Version 1

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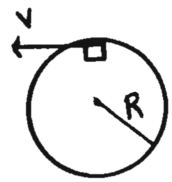
Lab Section Number

Exam 2 Chapts. 6-8 in Young&Geller

Multiple Choice questions. Circle the correct answer. No work needs to be shown.

(6 pts) 1. A small block with mass $m = 0.20$ kg moves on the inside of a circular track that has the shape of a vertical circle with radius $R = 2.0$ m. When the block is at the top of its circular path its speed is $v = 6.0$ m/s. At this point the normal force that the track exerts on the block has magnitude

(a) 1.64 N
(b) 1.96 N
(c) 4.44 N
(d) 5.56 N
(e) 8.36 N
(f) none of the above values



a

a ↓ n mg

$n + mg = m\frac{v^2}{R}$

$n = m\left(\frac{v^2}{R} - g\right) = (0.2)\left(\frac{(6)^2}{2} - 9.8\right)$ N

$n = 1.64$ N

(6 pts) 2. A satellite is in a circular orbit around a planet that has mass 9.60×10^{23} kg. The constant orbital speed of the satellite is 4000 m/s. The acceleration of the satellite in its orbit is

(a) zero
(b) 1.27 m/s^2
(c) 4.00 m/s^2
(d) 6.41 m/s^2
(e) 9.80 m/s^2
(f) none of the above values

c

$G\frac{m_p m}{r^2} = m\frac{v^2}{r}$

$\frac{Gm_p}{r} = v^2$

$r = \frac{Gm_p}{v^2}$

$a = \frac{v^2}{r} = \frac{v^4}{Gm_p}$

$a = \frac{(4000\,m/s)^4}{(6.67\times10^{-11}\,N\cdot m^2/kg^2)(9.6\times10^{23}\,kg)}$

$a = 4.00\ m/s^2$

(6 pts) 3. A block with mass 2.0 kg on a horizontal frictionless surface is pressed against a horizontal spring. The block is released from rest and moves along the surface. The spring has force constant 800 N/m. If the spring was initially compressed 0.080 m, what is the speed of the block when has left the spring?

(a) zero
(b) 1.2 m/s
(c) 1.6 m/s
(d) 1.8 m/s
(e) 2.4 m/s
(f) none of the above values

c

$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$

$v = x\sqrt{\frac{k}{m}} = (0.08)\sqrt{\frac{800}{2}} = 1.6\ m/s$

(6 pts) 4. A rock with mass 2.0 kg is projected from the ground with an initial velocity that has magnitude 12.0 m/s and direction 36.9° above the horizontal. Air resistance can be neglected. If the gravitational potential energy of the rock is zero at ground level, what is the gravitational potential energy of the rock when it is at its maximum height above the ground?

(a) 23.0 J
b (b) 51.8 J
(c) 64.0 J
(d) 70.6 J
(e) 144 J
(f) 196 J
(g) none of the above values

at max height, $V_f = V_i \cos 36.9° = 9.6\ m/s$

$K_i + U_i + W_{other} = K_f + U_f$

$U_f = K_i - K_f = \frac{1}{2}mv_i^2 - \frac{1}{2}mv_f^2 = \frac{1}{2}(2.0)((12)^2 - (9.6)^2)\ J$

$U_f = 51.8\ J$

(16 pts) 5. Block A with mass 3.0 kg and block B with mass 6.0 kg are at rest on a horizontal frictionless surface with a compressed spring between them. The blocks and spring are released and the blocks move off in opposite directions, leaving the spring behind. After the blocks leave the spring,

(a) the magnitude of the momentum of block A is greater than the magnitude of the momentum of block B

(b) the magnitude of the momentum of block A is less than ~~than~~ the magnitude of the momentum of block B

c (c) the magnitude of the momentum of block A is the same as the magnitude of the momentum of block B

On the following problems show all your work. Partial credit will be given if earned. Write your answers in the blanks provided.

(14 pts) 6. On a planet in a solar system far from ours, you release a rock from rest at a height of 12.0 m above the surface of the planet and you find that the rock has speed 8.0 m/s just before it reaches the surface. Air resistance can be neglected. The planet has radius 3.00×10^7 m. What is the mass of the planet?

$y - y_0 = 12\ m$
$V_{0y} = 0$
$V_y = 8\ m/s$
$a_y = ?$

$V_y^2 = V_{0y}^2 + 2a_y(y - y_0)$

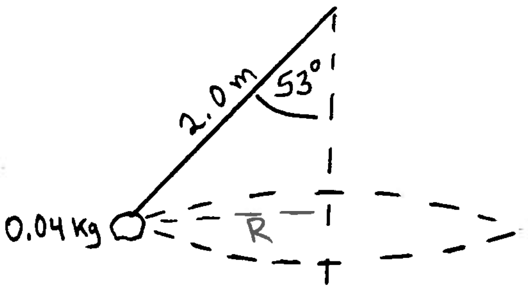
$a_y = \frac{V_y^2 - V_{0y}^2}{2(y - y_0)} = \frac{(8\ m/s)^2}{2(12\ m)} = 2.67\ m/s^2$

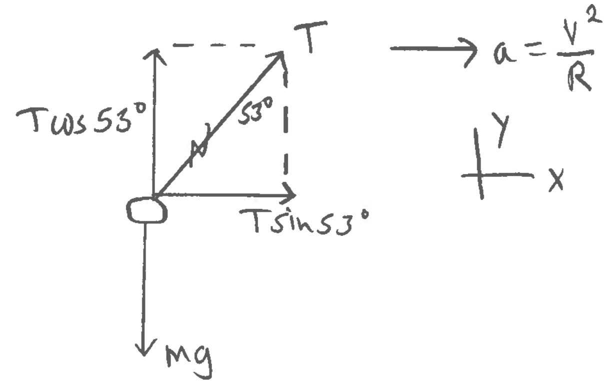
Ans. 3.60×10^{25} kg

$G\frac{m_p m}{R_p^2} = mg$

$m_p = \frac{R_p^2 g}{G} = \frac{(3 \times 10^7\ m)^2 (2.67\ m/s^2)}{6.67 \times 10^{-11}\ N \cdot m^2/kg^2} = 3.60 \times 10^{25}\ kg$

(18 pts) 7. A small rock of mass 0.040 kg is attached to one end of a 2.0 m long light string and swings in a horizontal circle at constant speed. The angle between the string and the vertical direction is 53° and is constant.





$R = 2.0\,m \sin 53° = 1.6\,m$

a) What is the tension in the string?

$\sum F_y = m a_y$

Ans. 0.651 N

$T \cos 53° - mg = 0$

$T = \frac{mg}{\cos 53°} = \frac{(0.040\,kg)(9.8\,m/s^2)}{\cos 53°} = 0.651\,N$

b) What is the speed of the rock?

$\sum F_x = m a_x$

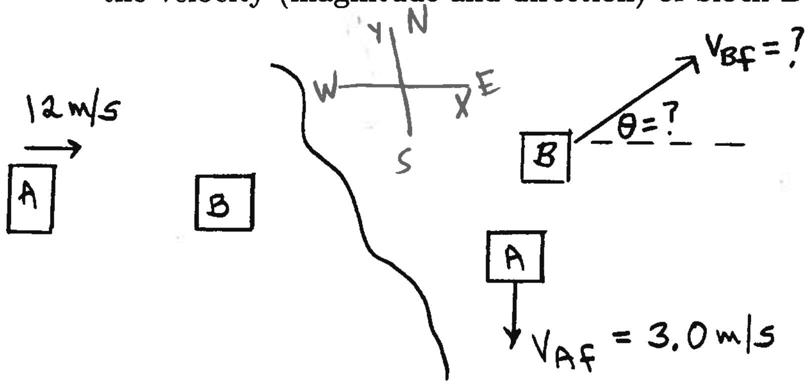
Ans. 4.56 m/s

$T \sin 53° = m \frac{v^2}{R}$

$v = \sqrt{\frac{R T \sin 53°}{m}} = \sqrt{\frac{(1.6\,m)(0.651\,N)\sin 53°}{0.04\,kg}}$

$v = 4.56\,m/s$

(18 pts). 8. Block A has mass 8.0 kg and is moving with a speed of 12.0 m/s on a horizontal frictionless surface. It strikes block B, that has mass 10.0 kg and that is initially at rest. After the collision block A is moving due south with a speed of 3.0 m/s. What is the velocity (magnitude and direction) of block B after the collision?



Ans. magnitude 9.90 m/s

direction 14.0°

$$P_{ix} = P_{fx}$$

$$(8\text{kg})(12\text{m/s}) = (10\text{kg})\, V_{Bfx}$$

$$V_{Bfx} = 9.6 \text{ m/s}$$

$$P_{iy} = P_{fy}$$

$$0 = (10\text{ kg})\, V_{Bfy} - (8\text{kg})(3.0\text{m/s})$$

$$V_{Bfy} = 2.4 \text{ m/s}$$

$$V_{Bf} = \sqrt{V_{Bfx}^2 + V_{Bfy}^2} = 9.90 \text{ m/s}$$

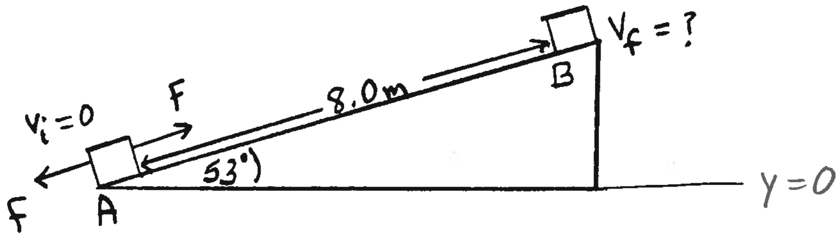
$$\tan\theta = \frac{V_{Bfy}}{V_{Bfx}} = \frac{2.4}{9.6} \qquad \theta = 14.0^\circ$$

Note: $K_i = \frac{1}{2}(8\text{ kg})(12\text{m/s})^2 = 576\text{ J}$

$$K_f = \frac{1}{2}(8\text{kg})(3\text{m/s})^2 + \frac{1}{2}(10\text{kg})(9.90\text{m/s})^2 = 526\text{ J}$$

$$K_f < K_i$$

(20 pts) 9. A box with mass 5.0 kg is initially at rest at point A at the bottom of a 8.0 m long ramp that is inclined at an angle of 53.0° above the horizontal. A worker applies a constant force $F = 70$ N that is parallel to the ramp and directed up the ramp in order to pull the box to the top of the ramp (point B). While the box is moving, the ramp exerts a constant friction force of 18.0 N on the box, directed down the ramp.



a) For the motion of the box from point A to point B, what is the work done on the box by gravity?

$W_{mg} = -(mg)(8m)\sin 53° = -(49N)(6.4m)$

$W_{mg} = -314\ J$

Ans. $-314\ J$

b) For the motion of the box from point A to point B, what is the work done on the box by the normal force that is exerted on the box by the ramp?

$W_n = 0$

Ans. 0

c) For the motion of the box from point A to point B, what is the work done on the box by the friction force that the ramp exerts on the box?

$W_f = -fs = -(18N)(8m) = -144\ J$

Ans. $-144\ J$

d) What is the speed of the box when it reaches the top of the ramp?

$K_i + U_i + W_{other} = K_f + U_f$

Ans. $6.39\ m/s$

$W_{other} = (70N)(8m) + (-144\ J) = 416\ J$

$U_i = 0 \quad U_f = mg(8m)\sin 53° = 314\ J$

$K_i = 0, \quad K_f = \frac{1}{2} m v_f^2$

$416\ J = \frac{1}{2} m v_f^2 + 314\ J$

$v_f = \sqrt{\frac{2(102\ J)}{5\ kg}} = 6.39\ m/s$