Key

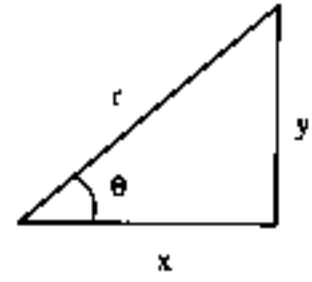
Physics 220 – Exam #2

October 18 **2000**

This exam consists of 12 problems on 7 pages. **Please check that you have them all.**

All of the formulas that you will need are given below. You may also use a calculator.

$\sin\theta = y/r$ $\cos\theta = x/r$ $\tan\theta = y/x$



average speed $= \frac{\text{distance traveled}}{\text{time}}$ $g = 9.8\ \text{m/s}^2$

1 mile = 1.6 km

average velocity $= \bar{v} = \frac{\text{displacement}}{\text{time}}$

instantaneous velocity = slope of position versus time

instantaneous acceleration = slope of velocity versus time

For constant acceleration:
$x = x_0 + v_0 t + \frac{1}{2}at^2$
$v = v_0 + at$
$v^2 = v_0^2 + 2a(x - x_0)$

$\vec{F} = m\vec{a}$
$F_{friction}^{max} = \mu_S N$ (static friction) $F_{friction} = \mu_K N$ (sliding friction)

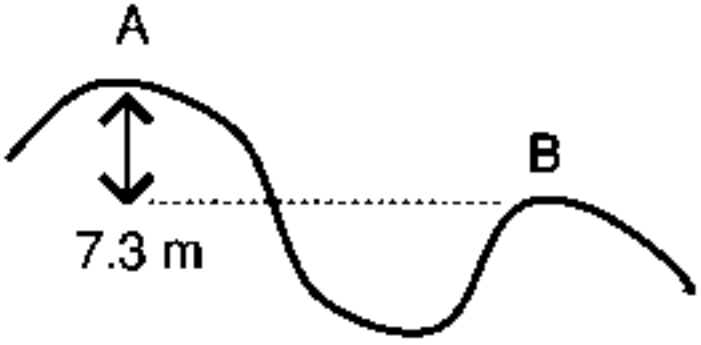
$F_{gravity} = \frac{Gm_1m_2}{r^2}$ $G = 6.67 \times 10^{-11}\ \text{Nm}^2/\text{kg}^2$

$a_c = v^2/r$ $KE = \frac{1}{2}mv^2$

$W = F\,d\cos\theta$ $PE_{gravity} = mgh$ power = work/Δt

$\vec{p} = m\vec{v}$ Δp = impulse $= F\,\Delta t$

1. A rollercoaster starts at the top of its track (point A) with a speed of 10 m/s. What will its speed be when it reaches point B? Assume that friction is negligible and ignore the kinetic energy of the wheels.



(a) 22 m/s
(b) 6.6 m/s
(c) 12 m/s
(d) 10 m/s
→ (e) 16 m/s

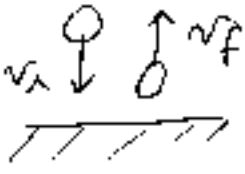
$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f$

$v_f^2 = v_i^2 + 2gh_i$

$v_f = \sqrt{10^2 + 2(9.8)(7.3)} = 16\ m/s$

2. Consider a rubber ball as it is dropped so as to bounce from a horizontal concrete floor. If the ball has a speed of 3.0 m/s just before striking the floor, and a speed of 2.5 m/s just after bouncing, find the average force of the floor on the ball. Assume that the ball is in contact with the floor for 0.12 s, and that the mass of the ball is 0.15 kg.

(a) 3.1 N
→ (b) 6.9 N
(c) 0.63 N
(d) 5.5 N
(e) 0.83 N



$v_f = +2.5$

$v_i = -3.0$

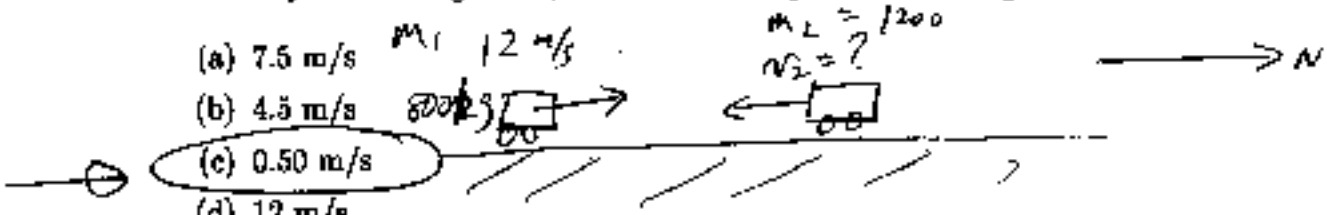
$F\Delta t = \Delta p = mv_f - mv_i$

$F = \frac{mv_f - mv_i}{\Delta t} = \frac{0.15[2.5 - (-3.0)]}{.012}$

$= \frac{0.15}{.12}(5.5) = 6.9\ N$

3. Two cars collide head-on and lock bumpers on an icy (frictionless) road. One car has a mass of 800 kg and an initial speed of 12 m/s and is moving towards the north. The other car has a mass of 1200 kg. If the speed of the cars after the collision is 4.5 m/s and they are moving north, find the initial speed of the large car.

(a) 7.5 m/s
(b) 4.5 m/s
(c) 0.50 m/s
(d) 12 m/s
(e) 18 m/s



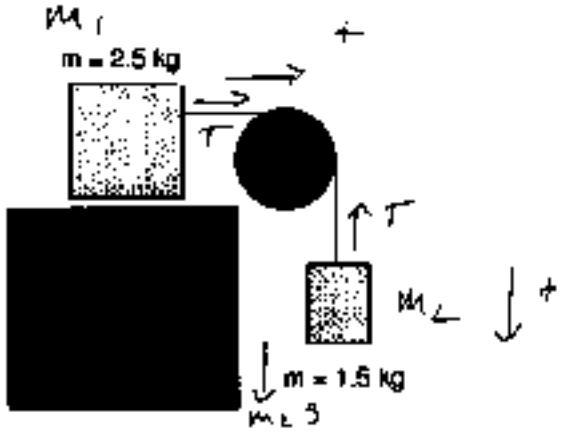
$P_i = P_f$ (total)

$m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$

$$v_{2i} = \frac{(m_1+m_2)v_f - m_1 v_{1i}}{m_2} = \frac{(800+1200)\,4.5 - 800(12)}{1200}$$

$= -0.50$ m/s Speed $= 0.5$ m/s

4. Two blocks are connected by a rope which runs over a pulley as shown in the figure. Find the acceleration of the mass on the right. Ignore friction, and assume that the masses of the rope and pulley are very small.



(a) 3.7 m/s²
(b) 9.8 m/s²
(c) zero
(d) 5.9 m/s²
(e) 6.7 m/s²

$m_2 a = m_2 g - T$
$m_1 a = T$

$(m_1 + m_2)a = m_2 g$

$$a = \frac{m_2 g}{m_1 + m_2} = \frac{1.5(9.8)}{2.5+1.5} = 3.7 \text{ m/s}^2$$

5. A rock of mass 7.2 kg is tied to a string of length 1.2 m. If one end of the string is held fixed, and the rock is swung in a vertical circle, find the minimum speed which the rock must have at the top of the circle without the string becoming slack.

(a) 12 m/s
(b) 9.2 m/s
(c) 3.4 m/s
(d) 7.4 m/s
(e) 1.4 m/s

$T = 0$ since the string is almost slack.

$mg + T = m\frac{v^2}{R}$ $\qquad \frac{v^2}{R} = g$

$v = \sqrt{gR} = \sqrt{9.8(1.2)} = \underline{\underline{3.4\ m/s}}$

6. A baseball which is initially traveling towards a batter with a speed of 40 m/s is struck by a bat and given an impulse of 18 kg-m/s. If the mass of the ball is 0.20 kg, and the ball is hit back towards the pitcher, find the speed of the ball just after it leaves the bat.

(a) 3.6 m/s
(b) 18 m/s
(c) 90 m/s
(d) 50 m/s
(e) 40 m/s

$v_i = -40$

$v_f = ?$

$F\Delta t = \text{impulse} = mv_f - mv_i$

$mv_f = F\Delta t - mv_i$

$v_f = \frac{F\Delta t - mv_i}{m} = \frac{18 - 0.20(40)}{0.20}$

$= \underline{\underline{50\ m/s}}$

7. A rubber ball of mass 0.12 kg is dropped from a height of 1.4 m above the floor. If the ball bounces back up to a height of 1.1 m, find the change in the total mechanical energy of the ball.

(a) 2.9 J
(b) 1.7 J
(c) 1.3 J
→ (d) 0.35 J
(e) zero

$\Delta E_{mech} = \Delta mgh$

$= mg\,\Delta h = 0.12(9.8)(1.4-1.1)$

$= 0.12(9.8)(0.3)$

$= 0.35\ J$

8. A car of mass 1200 kg is moving along a circular arc of radius 35 m. If the speed of the car is 12 m/s, find its centripetal acceleration.

(a) 4900 m/s^2
(b) 410 m/s^2
→ (c) 4.1 m/s^2
(d) 34 m/s^2
(e) 9800 m/s^2

$a_c = \frac{v^2}{R} = \frac{(12)^2}{35} = 4.1\ m/s^2$

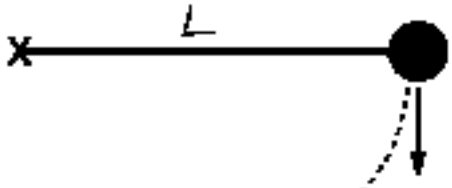
9. A baseball pitcher throws a pitch to a batter, and gives the ball (of mass 0.20 kg) an initial speed of 45 m/s. The batter makes contact, and sends the ball in the opposite direction with a speed of 35 m/s. What is the magnitude of the momentum of the ball just after it is hit?

(a) 16.0 N-s
(b) 9.0 N-s
(c) 7.0 kg-m/s
(d) 2.0 kg-m/s
(e) zero

$p = mv$

$= 0.20(35) = 7.0 \text{ kg m/s}$

10. A rock of mass 3.3 kg is tied to a string of length 1.2 m. The rock is held at rest as shown so that the string is initially tight, and then released. Find the speed of the rock when it reaches the lowest point of its trajectory.



$h_i = L = 1.2 \text{ m}$

$h_f = 0$

(a) 3.4 m/s
(b) 4.8 m/s
(c) 23 m/s
(d) 7.7 m/s
(e) 0.75 m/s

$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f$

($v_i = 0$, $h_f = 0$)

$v_f^2 = 2gh_i$

$v_f = \sqrt{2gh_i} = \sqrt{2(9.8)(1.2)} = 4.8 \text{ m/s}$

11. A satellite is put into orbit around the earth. If the period of the orbit is 90 minutes, and the radius of the orbit is 6.8×10^6 m, find the speed of the satellite.

(a) 450 m/s
(b) 2.9×10^6 m/s
(c) 1.8×10^8 m/s
(d) 7.9×10^3 m/s
(e) 4.7×10^4 m/s

$$v = \frac{2\pi R}{T} = \frac{2\pi (6.8 \times 10^6)}{90.60}$$

$$= 7900 \text{ m/s}$$

12. A baseball pitcher throws a pitch at a speed of 45 m/s. If the ball has a mass of 0.2 kg, find the work done by the pitcher on the ball.

(a) 2000 J
(b) 18 J
(c) 200 J
(d) 9.0 N
(e) 4.5 J

$$W = \Delta KE = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 \quad (v_i = 0)$$

$$= \frac{1}{2} (0.2)(45)^2 = 200 \text{ J}$$

The End