General Physics I **Exam 2 - Chs. 4,5,6 - Forces, Circular Motion, Energy** **Oct. 10, 2012**

Name Rec. Instr. Rec. Time

For full credit, make your work clear to the grader. Show formulas used, essential steps, and results with correct units and significant figures. Partial credit is available if your work is clear. Points shown in parenthesis. For TF and MC, choose the *best* answer.

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1. (3) A block of mass 1.5 kg is acted on by two forces: one of magnitude 3.0 N directed east and another of magnitude 3.0 N directed north. What can you say about the block's instantaneous motion?

a) It is moving to the east. b) It is moving to the north.
c) It is moving towards northeast. d) It must be at rest. e) It could be moving in any direction.

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2. (3) A 1.5 kg block is moving at constant speed towards due north. What can you conclude?

a) There is just one force towards the north acting on it. b) There is no net force acting on the block.
c) The net force on the block is directed towards the north. d) There are no forces acting on the block.

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3. (3) A 1.5 kg block is acted on by two forces: one of magnitude 3.0 N directed east and another of magnitude 3.0 N directed north. What can you say about the block's instantaneous acceleration?

a) The acceleration has a magnitude of 2.0 m/s^2. b) The acceleration has a magnitude of 2.8 m/s^2.
c) The acceleration has a magntiude of 4.0 m/s^2. d) The acceleration is zero.

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4. (3) A block slides to the right on a level surface. One force that acts on it is the "normal force" $\vec{N}$. The 3rd law pair force associated with $\vec{N}$ is the

a) force opposite to $\vec{N}$ that acts on the level surface. b) frictional force on the block.
c) force of gravity on the block due to the Earth. d) force of gravity on the Earth due to the block.

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5. (3) The two forces in a 3rd law action-reaction pair

a) can act on different objects or on the same object. b) always act on the same object.
c) always act on different objects.

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6. (2) **T F** On a level road, the normal force of the road on the tires can cause your car to accelerate.

7. (2) **T F** When present, static friction always prevents an object from accelerating.

8. (2) **T F** A body in "free fall" has no net force acting on it.

9. (2) **T F** The net force on a body that is not accelerating is zero.

10. (2) **T F** While sitting in your chair, your mass exerts a gravitational force on the Earth.

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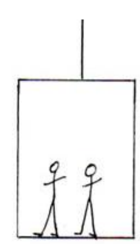
11. (10) An elevator together with its passengers weighs 4900 N. At a certain instant, the tension in its supporting cable is 5900 N. Determine the magnitude and direction of its instantaneous acceleration.



12. (16) A 1400-kg car initially has a velocity of 33.3 m/s due south. It brakes to a stop over a 180 m distance.

a) (6) What is the magnitude of the car's acceleration, in m/s^2?

b) (4) What average net force magnitude was necessary to stop the car?

c) (6) Assuming the tires do not skid, what coefficient of static friction between tires and pavement is needed?

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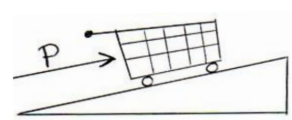
13. (12) A 32-kg filled grocery cart is to be pushed up a frictionless ramp by a pushing force P acting along the ramp, tilted at an angle of 6.0° above horizontal.



a) (6) What magnitude force P is needed to push the cart at constant speed?

b) (6) What magnitude P is needed to push the cart up the ramp with an acceleration of 2.0 m/s^2?

Name Rec. Instr. Rec. Time

14. (18) A centrifuge is used to swing some mass (usually a fluid) around in a horizontal circle at high speed, causing a large acceleration. Suppose the radius of the circle is 12.0 cm and the mass is 25.0 grams.

a) (6) At what speed v should the mass move so that its centripetal acceleration is $2.00 \times 10^3 g$? (where $g = 9.80$ m/s^2 is the acceleration due to gravity at Earth's surface)

b) (6) What is the rate of rotation, measured in revolutions per minute?

c) (6) Calculate the magnitude of the centripetal force acting on the 2.50 gram mass.

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15. (12) Jupiter's radius is 11.2 times Earth's radius and its mass is 318 times Earth's mass.

a) (6) Using the formula $g = GM/r^2$, which gives 9.80 m/s^2 at Earth's surface, how large is g in m/s^2 at the surface of Jupiter?

b) (6) A 12.0-kg satellite is to be placed into a circular orbit around Jupiter at an altitude above the surface equal to Jupiter's radius. Determine the centripetal acceleration of the satellite.

16. (12) A 1600-kg car accelerates from rest to a final speed of 40.0 m/s in a time of 6.00 s.

a) (6) What is the minimum work output of the motor, in kJ, during the 6.00 s acceleration?

b) (6) What minimum average power output of the motor is required, in kW?

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17. (2) **T F** When a mass is moved to a higher altitude, its gravitational PE increases.

18. (2) **T F** Friction is an example of a non-conservative force.

19. (2) **T F** Friction acting on a mass always does negative work.

20. (2) **T F** When you drive a car down a hill, gravity does no work on the car.

21. (2) **T F** A force does the most work on a mass when parallel to the displacement of the mass.

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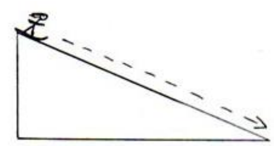
22. (18) A 70.0-kg skier slides down a uniform 30.0° slope of snow, starting from rest at the top of the hill. The distance traveled along the slope is 250 m.



a) (6) Assuming no friction, how large is her kinetic energy, in joules, at the bottom of the hill?

b) (6) How fast will the skier be going when she reaches the bottom of the hill?

c) (6) Suppose instead that the skier is slowed down by a kinetic friction force equal to $f_k = 60.0$ N up the slope. What would be her kinetic energy, in joules, at the bottom of the hill?

Score = ____________/133.

Prefixes

a=10^{-18}, f=10^{-15}, p=10^{-12}, n=10^{-9}, $\mu = 10^{-6}$, m=10^{-3}, c=10^{-2}, k=10^{3}, M=10^{6}, G=10^{9}, T=10^{12}, P=10^{15}

Physical Constants

$g = 9.80$ m/s^2 (gravitational acceleration)
$M_E = 5.98 \times 10^{24}$ kg (mass of Earth)
$m_e = 9.11 \times 10^{-31}$ kg (electron mass)
$c = 299792458$ m/s (speed of light)
$G = 6.67 \times 10^{-11}$ N·m^2/kg^2 (Gravitational constant)
$R_E = 6380$ km (mean radius of Earth)
$m_p = 1.67 \times 10^{-27}$ kg (proton mass)

Units and Conversions

1 inch = 1 in = 2.54 cm (exactly)
1 mile = 5280 ft
1 m/s = 3.6 km/hour
1 acre = 43560 ft^2 = (1 mile)^2/640
1 foot = 1 ft = 12 in = 30.48 cm (exactly)
1 mile = 1609.344 m = 1.609344 km
1 ft/s = 0.6818 mile/hour
1 hectare = 10^4 m^2

Trig summary

$\sin\theta = \frac{\text{(opp)}}{\text{(hyp)}}$, $\cos\theta = \frac{\text{(adj)}}{\text{(hyp)}}$, $\tan\theta = \frac{\text{(opp)}}{\text{(adj)}}$, $\text{(opp)}^2 + \text{(adj)}^2 = \text{(hyp)}^2$.
$\sin\theta = \sin(180° - \theta)$, $\cos\theta = \cos(-\theta)$, $\tan\theta = \tan(180° + \theta)$, $\sin^2\theta + \cos^2\theta = 1$.

Chapter 1 Equations

Percent error:
If a measurement = value ± error, the percent error $= \frac{\text{error}}{\text{value}} \times 100$ %.

Chapter 2 Equations

Motion:
$\bar{v} = \frac{\Delta x}{\Delta t}$, $\Delta x = x - x_0$, slope of $x(t)$ curve $= v(t)$.
$\bar{a} = \frac{\Delta v}{\Delta t}$, $\Delta v = v - v_0$, slope of $v(t)$ curve $= a(t)$.

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

For free fall on Earth, using an upward y-axis, with $g = 9.80$ m/s^2 downward:
$\bar{v}_y = \frac{1}{2}(v_{y0} + v_y)$, $v_y = v_{y0} - gt$, $y = y_0 + v_{y0}t - \frac{1}{2}gt^2$, $v_y^2 = v_{y0}^2 - 2g\Delta y$.

Chapter 3 Equations

Vectors
Written $\vec{V}$ or $\mathbf{V}$, described by magnitude=V, direction=θ or by components (V_x, V_y).
$V_x = V\cos\theta$, $V_y = V\sin\theta$,
$V = \sqrt{V_x^2 + V_y^2}$, $\tan\theta = \frac{V_y}{V_x}$. θ is the angle from $\vec{V}$ to x-axis.
Addition: $\mathbf{A} + \mathbf{B}$, head to tail. Subtraction: $\mathbf{A} - \mathbf{B}$ is $\mathbf{A} + (-\mathbf{B})$, $-\mathbf{B}$ is $\mathbf{B}$ reversed.

Projectiles
$a_x = 0$, $v_x = v_{x0}$, $x = x_0 + v_{x0}t$. For a horizontal x-axis.
$a_y = -g$, $v_y = v_{y0} - gt$, $y = y_0 + v_{y0}t - \frac{1}{2}gt^2$. For an upward y-axis.
$R = \frac{v_0^2}{g}\sin 2\theta_0$, (For level ground only.)

Relative Motion
$\vec{V}_{\text{BS}} = \vec{V}_{\text{BW}} + \vec{V}_{\text{WS}}$, B=Boat, S=Shore, W=Water.
BS means "boat relative to shore", etc.
Must be applied as a vector equation!

Chapter 4 Equations

Newton's Second Law:
$\vec{F}_{\text{net}} = m\vec{a}$, means $\Sigma F_x = ma_x$ and $\Sigma F_y = ma_y$. $\vec{F}_{\text{net}} = \sum \vec{F}_i$, sum over all forces on a mass.

Friction (magnitude):
$f_s \leq \mu_s N$ or $F_{\text{fr}} \leq \mu_s F_N$ (static friction). $f_k = \mu_k N$ or $F_{\text{fr}} = \mu_k F_N$. (kinetic or sliding friction)

Gravitational force near Earth:
$F_G = mg$, downward.

Chapter 5 Equations

Centripetal Acceleration:
$a_R = \frac{v^2}{r}$, towards the center of the circle.

Circular motion:
speed $v = \frac{2\pi r}{T} = 2\pi r f$, frequency $f = \frac{1}{T}$, where T is the period of one revolution.

Gravitation:
$F = G\frac{m_1 m_2}{r^2}$; $g = \frac{GM}{r^2}$, where $G = 6.67 \times 10^{-11}$ Nm^2/kg^2;

Orbits:
$\frac{v^2}{r} = g = \frac{GM}{r^2}$; $v = \sqrt{\frac{GM}{r}}$. centripetal acceleration = free fall acceleration.

Chapter 6 Equations

Work & Kinetic & Potential Energies:
$W = Fd\cos\theta$, $\text{KE} = \frac{1}{2}mv^2$, $\text{PE}_{\text{gravity}} = mgy$, $\text{PE}_{\text{spring}} = \frac{1}{2}kx^2$. θ = angle btwn $\vec{F}$ and $\vec{d}$.

Conservation or Transformation of Energy:

Work-KE theorem:
$\Delta\text{KE} = W_{\text{net}}$ = work of all forces.

General energy-conservation law:
$\Delta\text{KE} + \Delta\text{PE} = W_{\text{NC}}$ = work of non-conservative forces.

Power:
$P_{\text{ave}} = \frac{W}{t}$, or use $P_{\text{ave}} = \frac{\text{energy}}{\text{time}}$.