**General Physics I  Quiz 2 - OS Chs. 5,6,7 - Friction, Circular Motion, Energy  Mar. 2, 2023**

Rec. Time: Name:

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

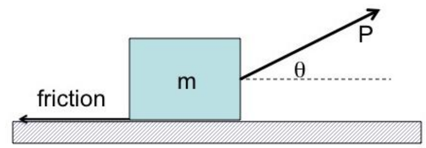
1. (3) A 25-kg shipping box rests on a level floor. You push on it with a 62-N horizontal force, but it doesn't move. The type and size of friction force of the floor acting on the box is

| | | |
|---|---|---|
| a. static, 0.0 N. | b. static, 62 N. | c. static, $f_s > 62$ N. |
| d. kinetic, 0.0 N. | e. kinetic, 62 N. | f. kinetic, $f_k > 62$ N. |

2. (3) A 15-kg shipping box can be pulled at constant speed on a level floor by a 98-N force. The type and size of friction force of the floor acting on the box is

| | | |
|---|---|---|
| a. static, 0.0 N. | b. static, 98 N. | c. static, $f_s > 98$ N. |
| d. kinetic, 0.0 N. | e. kinetic, 98 N. | f. kinetic, $f_k > 98$ N. |

3. (18) A 25-kg shipping pallet rests on a level wooden floor. A worker finds that a rope tension $P = 128$ N at $\theta = 30.0°$ above horizontal is required to get the pallet moving.




a) (6) How large is the normal force of the floor acting on the pallet?

b) (6) How large is the static coefficient of friction between floor and pallet?

c) (6) The worker pulls the pallet 2.0 m to the right. Select whether each force listed below does negative work, zero work, or positive work:

| | | | |
|---|---|---|---|
| Friction $f$. | a. $W_f < 0$. | b. $W_f = 0$. | c. $W_f > 0$. |
| Tension $P$. | a. $W_P < 0$. | b. $W_P = 0$. | c. $W_P > 0$. |
| Gravity $mg$. | a. $W_g < 0$. | b. $W_g = 0$. | c. $W_g > 0$. |

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4. (2) **T F** A static friction force on an object always prevents its motion.

5. (2) **T F** A kinetic friction force on an object always causes its speed to increase.

6. (2) **T F** At the optimum speed on a banked curve, friction is not needed to hold a car on the road.

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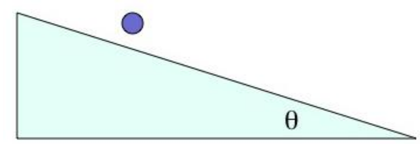
7. (18) A four-wheel-drive car (mass $m$) is descending an ice-covered road that has a $\theta = 5.0°$ slope. The coefficients of static and kinetic friction between the tires and road are $\mu_s = 0.100$ and $\mu_k = 0.050$ . The driver applies the brakes as strongly as possible without locking the wheels or skidding.

a) (6) The solid dot in the sketch here represents the car. Draw its free body diagram, showing and labeling all the forces on the car while braking.




b) (4) Write a formula for the normal force of the road on the car, in terms of the given symbols and $g$.

c) (8) Use Newton's 2nd Law to determine the magnitude and direction (uphill/downhill) of the car's acceleration. (Write the forces in terms of $mg$ to do this most easily.)

8. (3) Which point on a uniformly spinning pottery wheel has the highest linear speed?
   a. The center. b. A point halfway out. c. The outer edge. d. All points tie.

9. (3) Which point on a uniformly spinning pottery wheel has the highest rotational frequency?
   a. The center. b. A point halfway out. c. The outer edge. d. All points tie.

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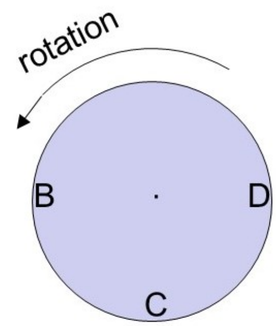
10. (20) Some kids are playing on a merry-go-round in a park. Tim uses his stopwatch and sees that one revolution takes 1.80 s. J.B. (mass = 44 kg) is riding at the edge, 2.4 m from the center, holding on for dear life.




a) (6) Calculate J.B.'s linear speed in m/s.

b) (6) Calculate J.B.'s centripetal acceleration, in units of $g$'s. Show its direction when J.B. is at point B in the diagram, with an arrow there.

c) (6) How large is the net force on J.B. at point C in the diagram? Show its direction in the diagram with an arrow at point C.

d) (2) J.B. lets go at point D. Draw an arrow at point D to indicate which way he flies off.

11. (2) **T F** When a force acts parallel to the displacement of a mass, it does the greatest work.

12. (2) **T F** A static friction force on an object cannot do any work.

13. (2) **T F** When you drive a car up an incline, gravity does negative work on it.

14. (2) **T F** When a compressed spring is released and allowed to expand, its potential energy increases.

15. (2) **T F** A conservative force is one that can store potential energy.

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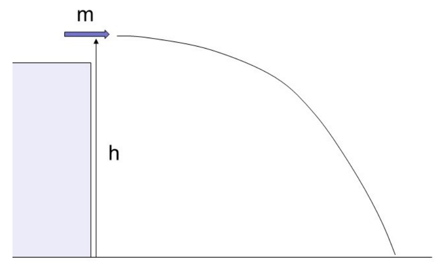
16. (20) An archer draws back a 120-gram arrow a distance $d = 0.70$ m in the bow, exerting up to a 150-N force before the arrow is released. The arrow is launched horizontally from a cliff at height $h = 25$ m above the valley below. Ignore air resistance.




a) (6) How much potential energy is stored in the bow before the arrow is released?

b) (6) With what speed does the arrow leave the bow (when it detaches from the string)?

c) (8) How fast is the arrow traveling just before it lands in the valley?

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

Trig summary

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

OpenStax Ch. 1 Equations

Percent uncertainty:

If a measurement = value ± uncertainty, percent uncertainty = (uncertainty/value) × 100 %.

OpenStax Ch. 2 Equations

Motion:

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

Quadratic eqn.: $ax^2 + bx + c = 0$.
Solution: $x = \left[-b \pm \sqrt{b^2 - 4ac}\,\right]/(2a)$.

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:

$\bar{v}_y = \frac{1}{2}(v_{0y} + v_y)$, $v_y = v_{0y} - gt$, $y = y_0 + v_{0y}t - \frac{1}{2}gt^2$, $v_y^2 = v_{0y}^2 - 2g\Delta y$.

OpenStax Ch. 3 Equations

Vectors

Written $\vec{V}$ or $\mathbf{V}$, described by magnitude=$V$, direction=$\theta$ or by components $(V_x, V_y)$.
$V_x = V\cos\theta$, $V_y = V\sin\theta$,
$V = \sqrt{V_x^2 + V_y^2}$, $\tan\theta = V_y/V_x$. $\theta$ 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

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

## OpenStax Ch. 4 Equations

Newton's First Law:
$\vec{a} = 0$ unless $\vec{F}_{\text{net}} \neq 0$.

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.

Newton's Third Law:
$\vec{F}_{\text{A on B}} = -\vec{F}_{\text{B on A}}$.

Gravitational force (weight) near Earth:
$F_g = mg$, downward.

Gravitational force components on inclines:
$F_{g\|} = mg\sin\theta$, $F_{g\perp} = mg\cos\theta$, for incline at angle $\theta$ to horizontal.

## OpenStax Ch. 5 Equations

Normal force $N$

$N$ is the force acting perpendicular to a surface, on the object acted on by friction.

Friction magnitude (opposes the relative motion of two surfaces) depends on $N$:
$f_s \leq \mu_s N$ (static friction). $f_k = \mu_k N$ (kinetic or sliding friction).

## Chapter 6 Equations

Centripetal Acceleration:
$a_c = v^2/r = \omega^2 r$, towards the center of the circle. Use $\omega$ in rad/sec!

Circular motion:
speed $v = 2\pi r/T = 2\pi r f$, frequency $f = 1/T$, where $T$ is the period of one revolution.
speed $v = \omega r$, angular speed $\omega = 2\pi f = 2\pi/T$, $\omega$ is in rad/sec.

Gravitation:
$F = Gm_1m_2/r^2$; $g = GM/r^2$, where $G = 6.67 \times 10^{-11}$ Nm$^2$/kg$^2$;

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

## Chapter 7 Equations

Work & Kinetic & Potential Energies: $F_{\text{gravity},y} = -mg$, $F_{\text{spring}} = -kx$.
$W = Fd\cos\theta$, $\text{KE} = \frac{1}{2}mv^2$, $\text{PE}_{\text{gravity}} = mgy$, $\text{PE}_{\text{spring}} = \frac{1}{2}kx^2$. $\theta$ = 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-transformation law:**
$\Delta\text{KE} + \Delta\text{PE} = W_{\text{NC}}$ = work of non-conservative forces.

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