Physics 101	Hour Exam 1	October 6, 2014

Last Name: _______________ **First Name** _______________ **ID** _______________

Discussion Section: ____________________ **Discussion TA Name:** ____________________

Instructions—Turn off your cell phone and put it away.
Calculators cannot be shared. Please keep yours on your own desk.

This is a closed book exam. You have 90 minutes to complete it.
This is a multiple choice exam. Use the bubble sheet to record your answers.

1. Use a #2 pencil; do **not** use a mechanical pencil or a pen. Fill in completely (until there is no white space visible) the circle for each intended input – both on the identification side of your answer sheet and on the side on which you mark your answers. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner.

2. Print your last name in the **YOUR LAST NAME** boxes on your answer sheet and print the first letter of your first name in the **FIRST NAME INI** box. Mark (as described above) the corresponding circle below each of these letters.

3. Print your NetID in the **NETWORK ID** boxes, and then mark the corresponding circle below each of the letters or numerals. Note that there are different circles for the letter "I" and the numeral "1" and for the letter "O" and the numeral "0". **Do not** mark the hyphen circle at the bottom of any of these columns.

4. You may find the version of **this Exam Booklet at the top of page 2**. Mark the version circle in the **TEST FORM** box in the bottom right on the front side of your answer sheet. **DO THIS NOW!**

5. Stop **now** and double-check that you have bubbled-in all the information requested in 2 through 4 above and that your marks meet the criteria in 1 above. Check that you do not have more than one circle marked in any of the columns.

6. Print your UIN# in the **STUDENT NUMBER** designated spaces and mark the corresponding circles. You need not write in or mark the circles in the SECTION box.

7. Write in your course on the **COURSE LINE** and on the **SECTION** *line*, print your **DISCUSSION SECTION**. (You need not fill in the INSTRUCTOR line.)

8. Sign **(DO NOT PRINT)** your name on the **STUDENT SIGNATURE** *line*.

*Before starting work, check to make sure that your test booklet is complete. After these instructions, you should have **9** **numbered pages** plus 2 Formula Sheets.*

On the test booklet:
Write your **NAME**, your **Discussion TA's NAME**, your **DISCUSSION SECTION** and your **NETWORK-ID**. Also, write your **EXAM ROOM** and **SEAT NUMBER**.

When you are finished, you must <u>hand in BOTH the exam booklet AND the answer sheet</u>. Your exam will not be graded unless both are present.

<u>Academic Integrity</u>—**Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including expulsion.**

This Exam Booklet is Version A. Mark the **A** circle in the **TEST FORM** box in the bottom right on the front side of your answer sheet. **DO THIS NOW!**

Exam Format & Instructions:

This exam is a combination of
* Three-Answer Multiple Choice (3 points each)
* Five-Answer Multiple Choice (6 points each)

There are 23 problems for a maximum possible raw score of 105points.

Instructions for Three-Answer Multiple Choice Problems:
Indicate on the answer sheet the correct answer to the question (*a, b* or *c*).
Each question is worth 3 points. If you mark the wrong answer, or mark more than one answer, you receive 0 points.

Instructions for Five-Answer Multiple Choice Problems:
Indicate on the answer sheet the correct answer to each question (*a, b, c, d* or *e*).
Credit is awarded in the following way:
- If you mark one answer and it is correct, you will receive 6 points;
- If you mark two answers, and one of them is correct, you will receive 3 points;
- If you mark three answers and one of them is correct, you will receive 2 points.
- If you mark no answer or more than three answers, you will receive 0 points.

1) A disc which is initially at rest at $t = 0$ starts to rotate with a constant angular acceleration of 65 rad/s^2. How many complete revolutions has the disk made after 5 seconds?

$$\theta = \theta_0^{\approx 0} + \omega_0^{\approx 0} t + \frac{1}{2}\alpha t^2$$

$$\theta = \frac{1}{2}\alpha t^2 = \frac{1}{2} 65 \frac{rad}{s^2} \times (5s)^2 = 812.5 \text{ rad}$$

$$Rev = \frac{\theta}{2\pi} = \frac{812.5}{2\pi} = 129.3$$

a. 812 revolutions
b. 259 revolutions
c. 517 revolutions
d. 129 revolutions
e. 65 revolutions

The next two questions pertain to the situation described below.

An astronaut of mass 70 kg is floating in the void of space repairing a small satellite of mass 120 kg. After she has finished the repairs she gives the satellite a push of F = 200 N.

2) During the push, what is the magnitude of the acceleration of the astronaut ?

$$F = ma \Rightarrow a = \frac{F}{m} = \frac{200 \text{ N}}{70 \text{ Kg}} = 2.86 \text{ m/s}^2$$

a. 2.86 m/s^2
b. 1.67 m/s^2
c. 0 m/s^2
d. 1.05 m/s^2
e. 4 m/s^2

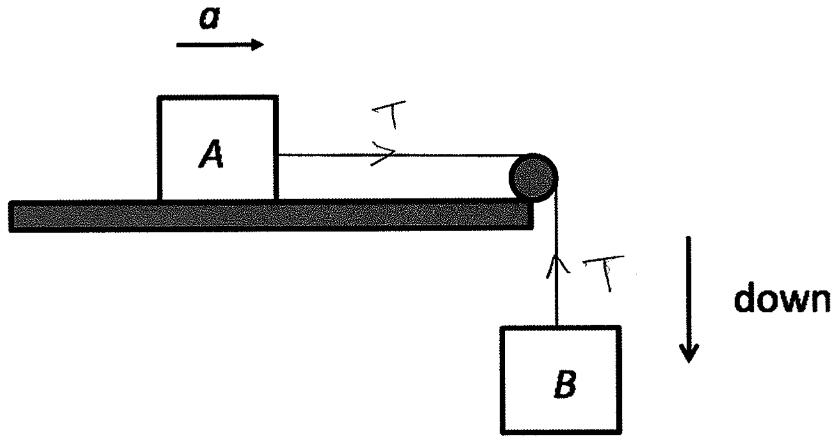
3) During the push, which of the following statements best describes the magnitude of the acceleration of the satellite ?

satellite heavier than astronaut

a. It is smaller than the magnitude of the acceleration of the astronaut.
b. It is equal to the magnitude of the acceleration of the astronaut.
c. It is bigger than the magnitude of the acceleration of the astronaut.

The next two questions pertain to the situation described below.

Consider two blocks connected by mass-less rope across a frictionless pulley as shown in the figure. Block A can slide across a frictionless horizontal surface and block B hangs vertically downwards. The mass of block A is $M_A = 8$ kg, and the mass of block B is $M_B = 11$ kg.



4) What is the magnitude of the acceleration of mass A?

a. 35.93 m/s^2
b. 12.05 m/s^2
c. 5.67 m/s^2
d. 13.48 m/s^2
e. 9.8 m/s^2

$$\left.\begin{array}{l} T = M_A a \\ T - M_B g = -M_B a \end{array}\right\} \quad M_A a = M_B g - M_B a$$

$$(M_A + M_B)\, a = M_B g$$

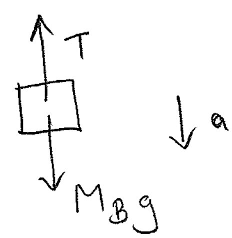
$$a = g \frac{M_B}{M_A + M_B}$$

$$= 9.8 \text{ m/s}^2 \frac{11}{8 + 11}$$

$$= 5.67 \text{ m/s}^2$$

5) How does the tension in the string, T, compare to the weight of block B?

a. $T > M_B * g$
b. $T = M_B * g$
c. $T < M_B * g$



$$T - M_B g = -M_B a$$

$$T = M_B g - M_B a < M_B g$$

6) Two identical balls are thrown horizontally off a tall building at the same time. Ball 1 is thrown at 4 m/s, and Ball 2 is thrown at 3 m/s. Neglecting air resistance, which ball hits the ground first?

a. Ball 1 hits the ground first.
b. Ball 2 hits the ground first.
c. They hit the ground at the same time.

The next two questions pertain to the situation described below.

An object having mass $M = 3$ kg moves around a circular path of radius R with a constant speed $V = 20$ m/s.

7) Suppose the centripetal force on the object is 1400 N. What is the radius of the circular path?

a. $R = 0.29$ m
b. $R = 1.71$ m
c. $R = 0.86$ m
d. $R = 0.04$ m
e. $R = 1.21$ m

$$F = ma = m\frac{v^2}{R} \Rightarrow R = \frac{mv^2}{F} = \frac{3\text{ kg} \times (20\text{ m/s})^2}{1400\text{ N}}$$

$$= 0.857\text{ m}$$

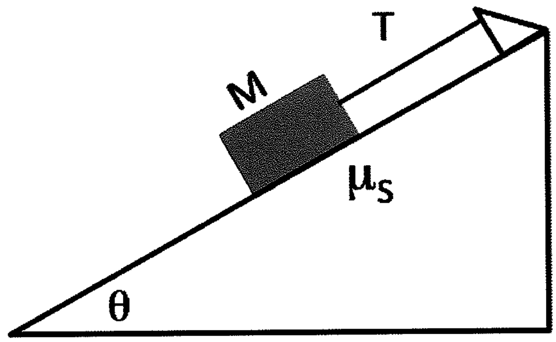
8) If both R and V are doubled, the centripetal force on the object:

a. Increases by a factor of 2.
b. Does not change.
c. Increases by a factor of 4.

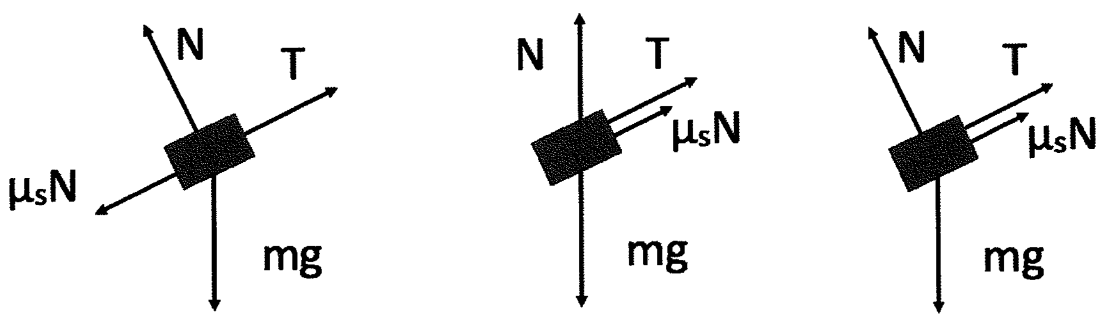
$$F = m\frac{v^2}{R} \rightarrow m\frac{(2v)^2}{2R} = 2m\frac{v^2}{R}$$

The next two questions pertain to the situation described below.

A block of mass M = 3 kg is placed on an inclined plane with an angle θ = 36 degrees. A string anchored near the top of the ramp is attached to the block in order to prevent the block from sliding down the ramp. (Without the string, static friction alone would be insufficient to keep the block from slipping.) The coefficient of static friction is $\mu_S = 0.08$ and the tension in the string is T.



9) Which is the correct free body diagram of the forces on the block when it is at rest?

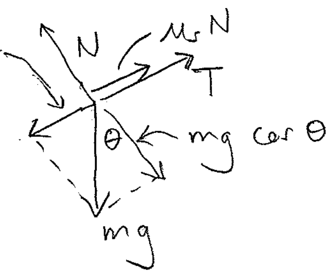


A B C

a. A (left diagram)
b. C (right diagram)
c. B (center diagram)

10) What is the minimum tension in the string needed to hold the block in place ?

a. 15.38 N
b. 5.13 N
c. 19.18 N
d. 22.4 N
e. 25.17 N



$N = mg\cos\theta$

$T + \mu_s N = mg\sin\theta$

$T = mg\sin\theta - \mu_s mg\cos\theta$

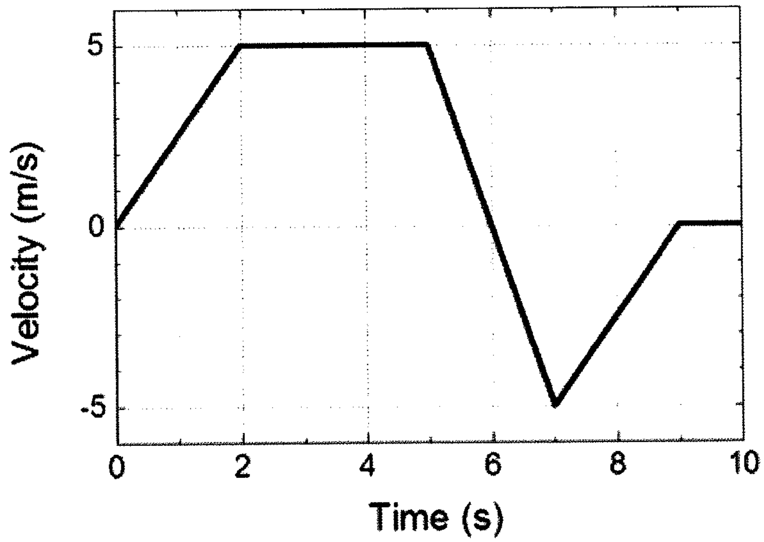
$= mg(\sin\theta - \mu_s\cos\theta)$

$= 3\,kg \times 9.8\,m/s^2 \times (\sin 36 - 0.08\cos 36)$

$= 15.38\,N$

The next two questions pertain to the situation described below.

A person drives a cart along a straight track. The velocity of the cart changes over time as shown in the graph.



11) What is the average acceleration of the cart between t = 2 s and t = 7 s?

a. -5 m/s^2
b. -2 m/s^2
c. -3.3 m/s^2
d. 2 m/s^2
e. 3.3 m/s^2

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{-5\ m/s - 5\ m/s}{5s} = -2\ m/s^2$$

12) What is the displacement of the cart between t = 0 s and t = 10 s ?

a. 15 m
b. 5 m
c. 0 m

Area under curve

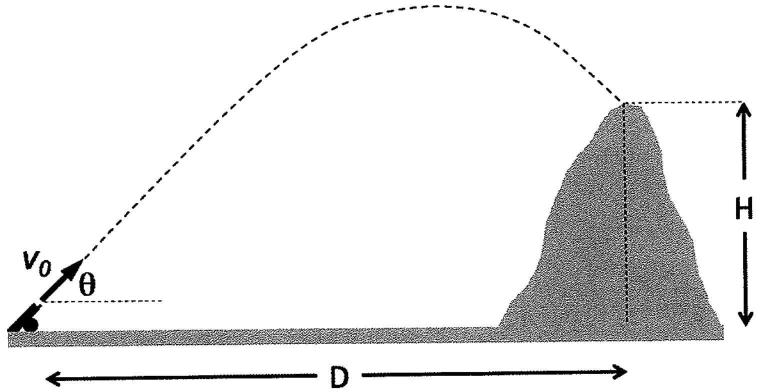
$$= \frac{1}{2}\,2s \times 5\ m/s + 3s \times 5\ m/s + \frac{1}{2}\,1s \times 5\ m/s + \frac{1}{2}\,1s\,(-5\ m/s) + \frac{1}{2}\,2s \times (-5\ m/s)$$

$$= (5 + 15 + 1/2 - 1/2 - 5)\ m$$

$$= 15\ m$$

The next three questions pertain to the situation described below.

A cannon ball is fired with initial speed $v_0 = 130$ m/s at an angle of $\theta = 56$ degrees above horizontal. After 16.48 seconds it strikes the top of the hill as shown.



13) What is the vertical distance *H* between the firing point and the top of the hill ?

a. 810.25 m
b. 1332.15 m
c. 2142.4 m
d. 443.98 m
e. 1776.13 m

$$\underset{=H}{y} = \underset{=0}{y_0} + v_{0y} t - \frac{1}{2} g t^2$$

$$H = 130\ \text{m/s} \sin 56 \times 16.48\ \text{s} - \frac{1}{2}\ 9.8\ \text{m/s}^2 \times (16.48\ \text{s})^2$$

$$= 445\ \text{m}$$

14) What is the horizontal distance *D* between the firing point and the top of the hill ?

a. 1198.01 m
b. 2142.4 m
c. 1776.13 m
d. 131.44 m
e. 161.67 m

$$D = v_{0x} t$$

$$= 130\ \text{m/s} \times \cos 56 \times 16.48\ \text{s}$$

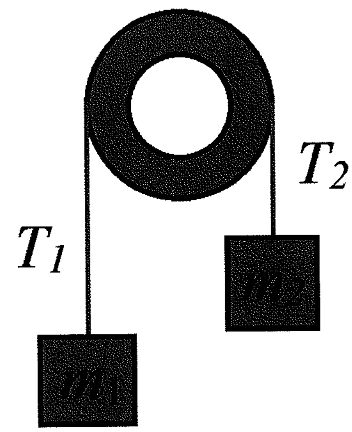
$$= 1198\ \text{m}$$

15) Which of the following statements best describes the speed of the cannon ball when it hits the hill ?

a. It is equal to v_0
b. It is greater than v_0
c. It is smaller than v_0

The next two questions pertain to the situation described below.

Two blocks are connected via a massless rope hanging over a frictionless pulley as shown. Their masses are $m_1 = 3$ kg and $m_2 = 5$ kg. The tension in the rope is denoted as T_1 and T_2.

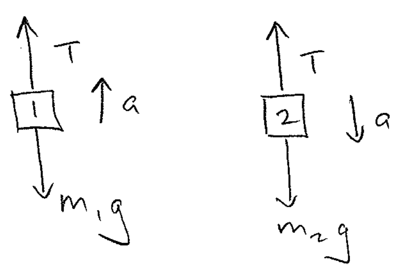


16) Which of the following statements is true?

a. The two blocks will move with the same absolute acceleration
b. The tension T_2 is equal to $m_2 g$
c. $T_2 > T_1$ since $m_2 > m_1$

17) What is the tension T_2 in the rope? Note: $T_1 = T_2$

a. 9.8 N
b. 41.7 N
c. 29.4 N
d. 36.8 N
e. 56.4 N



$\times m_2$ $\quad T - m_1 g = m_1 a \qquad T - m_2 g = -m_2 a \quad \times m_1$

$$\Downarrow \qquad\qquad \Downarrow$$

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

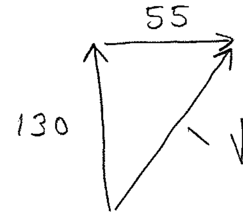
Add these 2 equations, RHS cancels:

$$T(m_2 + m_1) - 2 m_1 m_2 g = 0$$

$$T = \frac{2 m_1 m_2 g}{m_2 + m_1} = 2 \times 9.8\ m/s^2 \times \frac{3\ kg \times 5\ kg}{(5+3)\ kg}$$

$$= 36.75\ N$$

18) An airplane is flying on a windy day. The compass in the cockpit says that the nose of the plane is pointing north, and the air-speed indicator (which measures the airplane speed with respect to the air) says that it is travelling at 130 miles/hr. An observer on the ground measures that the air is moving east at 55 miles/hr (i.e. wind). What is the speed of the airplane as measured by the observer on the ground?



$\sqrt{(130)^2 + (55)^2} = 141.16$

a. 117.79 miles/hr
b. 185 miles/hr
c. 130 miles/hr
d. 55 miles/hr
e. 141.16 miles/hr

The next three questions pertain to the situation described below.

An object which weighs 16 N when at rest is placed on a scale in an elevator.

19) If the elevator is moving upward and its speed is constant, the scale will record a value that is

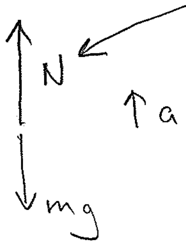
a. Greater than 16 N.
b. Less than 16 N.
c. Equal to 16 N.

20) If the elevator is moving down and its speed is decreasing, the scale will record a value that is

a. Equal to 16 N.
b. Less than 16 N.
c. Greater than 16 N.

21) If the reading of the scale is 18 N, the acceleration of the elevator must be

a. 1.2 m/s^2 downward
b. 2 m/s^2 downward
c. 1.2 m/s^2 upward
d. 2 m/s^2 upward
e. 0.0 m/s^2



normal force

$N - mg = ma$

Newtons

$18\ N - 16\ N = ma$

$2\ N = ma$

$\Downarrow$

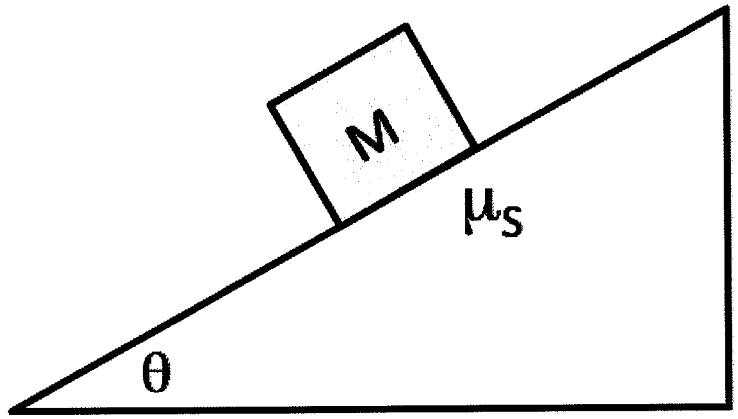
$a = \frac{2N}{m} = \frac{2N \times g}{mg}$

$= \frac{2N \times 9.8\ m/s^2}{16\ N}$

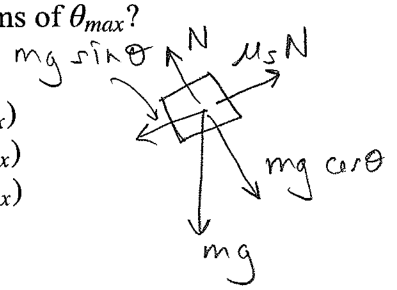
$= 1.225\ m/s^2$

The next two questions pertain to the situation described below.

A box of mass M sits on an inclined plane that makes an angle θ with the horizontal. Static friction keeps the box from moving. The coefficient of static friction between the box and the inclined plane is μ_S.



22) Suppose the angle of the incline is increased slowly, and that the maximum value of θ for which the box does not start to slip is found to be θ_{max}. What is the value of the coefficient of static friction in terms of θ_{max}?



$N = mg\cos\theta$

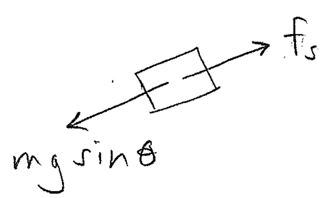
$\mu_s N = mg\sin\theta$ $\Rightarrow$ $\mu_s mg\cos\theta = mg\sin\theta$.

$\mu_s = \tan\theta$

a. $sin(\theta_{max})$
b. $tan(\theta_{max})$
c. $cos(\theta_{max})$

23) When the angle of the inclined plane is set to $\theta_2 = \dfrac{\theta_{max}}{2}$, what is the magnitude of the static frictional force acting on the box?

a. $Mgsin(\theta_2)$
b. $\mu_s Mgsin(\theta_2)$
c. $Mg/2$
d. $\mu_s Mgcos(\theta_2)$
e. $\mu_s Mgsin(\theta_2)$



$f_s = mg\sin\theta$

Physics 101 Formulas

Kinematics

$\mathbf{v}_{ave} = \Delta\mathbf{x}/\Delta t$ $\quad \mathbf{a}_{ave} = \Delta\mathbf{v}/\Delta t$

$v = v_0 + at \quad x = x_0 + v_0t + {}^1/_2at^2 \quad v^2 = v_0^2 + 2a\Delta x$

$g = 9.8\ m/s^2 = 32.2\ ft/s^2$ (near Earth's surface)

Dynamics

$\Sigma\mathbf{F} = m\mathbf{a} \quad F_g = Gm_1m_2 / R^2 \quad F_g = mg$ (near Earth's surface)

$f_{s,max} = \mu_sF_N$ $\quad$ Gravitational constant, $G = 6.7 \times 10^{-11}\ N{\cdot}m^2/kg^2$

$f_k = \mu_kF_N \quad a_c = v^2 / R = \omega^2R$

Work & Energy

$W_F = FD\cos(\theta) \quad K = {}^1/_2mv^2 = p^2/2m \quad W_{NET} = \Delta K = K_f - K_i \quad E = K + U$

$W_{nc} = \Delta E = E_f - E_i = (K_f + U_f) - (K_i + U_i)$

$U_{grav} = mgy$

Impulse & Momentum

Impulse $\mathbf{I} = \mathbf{F}_{ave}\Delta t = \Delta\mathbf{p} \quad \mathbf{F}_{ave}\Delta t = \Delta\mathbf{p} = m\mathbf{v}_f - m\mathbf{v}_i \quad \mathbf{F}_{ave} = \Delta\mathbf{p}/\Delta t$

$\Sigma\mathbf{F}_{ext}\Delta t = \Delta\mathbf{P}_{total} = \mathbf{P}_{total,final} - \mathbf{P}_{total,initial}$ (momentum conserved if $\Sigma\mathbf{F}_{ext} = 0$)

$\mathbf{x}_{cm} = (m_1\mathbf{x}_1 + m_2\mathbf{x}_2)/(m_1 + m_2)$

Rotational Kinematics

$\omega = \omega_0 + \alpha t \quad \theta = \theta_0 + \omega_0t + {}^1/_2\alpha t^2 \quad \omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

$\Delta x_T = R\Delta\theta \quad v_T = R\omega \quad a_T = R\alpha$ (rolling without slipping: $\Delta x = R\Delta\theta \quad v = R\omega \quad a = R\alpha$)

1 revolution = 2π radians

Rotational Statics & Dynamics

$\tau = Fr\sin\theta$

$\Sigma\tau = 0$ and $\Sigma F=0$ (static equilibrium)

$\Sigma\tau = I\alpha$

$I = \Sigma mr^2$ (for a collection of point particles)

$I = {}^1/_2MR^2$ (solid disk or cylinder) $\quad I = {}^2/_5MR^2$ (solid ball) $\quad I = {}^2/_3MR^2$ (hollow sphere)

$I = MR^2$ (hoop or hollow cylinder) $\quad I = {}^1/_{12}\ ML^2$ (uniform rod about center)

$W = \tau\theta$ (work done by a torque)

$\mathbf{L} = I\boldsymbol{\omega} \quad \Sigma\boldsymbol{\tau}_{ext}\Delta t = \Delta\mathbf{L}$ (angular momentum conserved if $\Sigma\tau_{ext} = 0$)

$K_{rot} = {}^1/_2I\omega^2 = L^2/2I \quad K_{total} = K_{trans} + K_{rot} = {}^1/_2mv^2 + {}^1/_2I\omega^2$

Simple Harmonic Motion

Hooke's Law: $F_s = -kx$

$U_{spring} = {}^1/_2kx^2$

$x(t) = A\cos(\omega t)$ $\quad$ or $\quad x(t) = A\sin(\omega t)$

$v(t) = -A\omega\sin(\omega t)$ $\quad$ or $\quad v(t) = A\omega\cos(\omega t)$

$a(t) = -A\omega^2\cos(\omega t)$ $\quad$ or $\quad a(t) = -A\omega^2\sin(\omega t)$

$\omega^2 = k/m \quad T = 2\pi/\omega = 2\pi\sqrt{m/k} \quad f = 1/T$

$x_{max} = A \quad v_{max} = \omega A \quad a_{max} = \omega^2A \quad \omega = 2\pi f$

For a simple pendulum $\omega^2 = g/L$, $T = 2\pi\sqrt{L/g}$

Fluids

$P = F/A$, $P(d) = P(0) + \rho g d$ change in pressure with depth d

Buoyant force $F_B = \rho g V_{dis}$ = weight of displaced fluid

Flow rate $Q = v_1 A_1 = v_2 A_2$ continuity equation (area of circle $A = \pi r^2$)

$P_1 + {}^1/_2\rho v_1^2 + \rho g y_1 = P_2 + {}^1/_2\rho v_2^2 + \rho g y_2$ Bernoulli equation

$\rho_{water} = 1000\ kg/m^3$ $1m^3 = 1000$ liters

$\rho = M/V$ 1 atmos. = 1.01×10^5 Pa   1 Pa = 1 N/m^2

Temperature and Heat

Temperature: Celsius (T_C) to Fahrenheit (T_F) conversion: $T_C = (5/9)(T_F - 32)$

Celsius (T_C) to Kelvin (T_K) conversion: $T_K = T_C + 273$

$\Delta L = \alpha L_0 \Delta T$ $\Delta V = \beta V_0 \Delta T$ thermal expansion

$Q = cM\Delta T$ specific heat capacity

$Q = L_f M$ latent heat of fusion (solid to liquid) $Q = L_v M$ latent heat of vaporization

$Q = \kappa A \Delta T t/L$ conduction

$Q = e\sigma T^4 At$ radiation   ($\sigma = 5.67 \times 10^{-8}\ J/(s \cdot m^2 \cdot K^4)$)

$P_{net} = e\sigma A(T^4 - T_0^4)$ (surface area of a sphere $A = 4\pi r^2$)

Ideal Gas & Kinetic Theory

$N_A = 6.022 \times 10^{23}$ molecules/mole   Mass of carbon-12 = 12.000 u

$PV = nRT = Nk_BT$ $R = 8.31\ J/(mol \cdot K)$ $k_B = R/N_A = 1.38 \times 10^{-23}\ J/K$

$KE_{ave} = {}^3/_2 k_BT = {}^1/_2 mv_{rms}^2$ $U = {}^3/_2 Nk_BT$ (internal energy of a monatomic ideal gas)

$v_{rms}^2 = 3k_BT/m = 3RT/M$ (M = molar mass = kg/mole)

Thermodynamics

$\Delta U = Q + W$ (1'st law)

$U = ({}^3/_2)nRT$ (internal energy of a monatomic ideal gas for fixed n)

$C_V = ({}^3/_2)R = 12.5\ J/(mol \cdot K)$ (specific heat at constant volume for a monatomic ideal gas)

$Q_H + Q_C + W = 0$ (heat engine or refrigerator)

$e = -W/Q_H = 1 + Q_C/Q_H$ $e_{max} = 1 - T_C/T_H$ (Carnot engine)

$-Q_C/Q_H = T_C/T_H$ at maximum efficiency (2'nd law)

$W = -P\Delta V$ (work done by expanding gas)

Harmonic Waves

$v = \lambda / T = \lambda f$

$v^2 = F/(m/L)$ for wave on a string

$v = c = 3 \times 10^8$ m/s for electromagnetic waves (light, microwaves, etc.)

$I = P/(4\pi r^2)$ (sound intensity)

Sound Waves

Loudness: $\beta = 10 \log_{10}(I/I_0)$ (in dB), where $I_0 = 10^{-12}\ W/m^2$

$$f_{observer} = f_{source} \frac{v_{wave} - v_{observer}}{v_{wave} - v_{source}}$$ (Doppler effect)