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. You should have **11** **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 mixture of

∗ Two-Answer Multiple Choice	(2 points each)
∗ Three-Answer Multiple Choice	(3 points each)
∗ Five-Answer Multiple Choice	(6 points each)

There are 25 problems for a maximum possible raw score of 110 points.

<u>Instructions for Two-Answer Multiple Choice Problems:</u>
Indicate on the answer sheet the correct answer to the question (*a* or *b*).
Each question is worth 2 points. If you mark the wrong answer, or mark more than one answer, you receive 0 points.

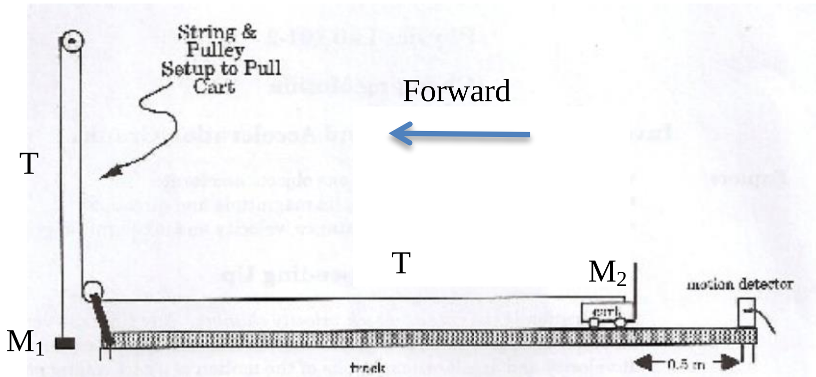
<u>Instructions for Three-Answer Multiple Choice Problems:</u>
Indicate on the answer sheet the correct answer to the question (*a*, *b* or *c*).
Each question is worth 3 points. If you mark the wrong answer, or mark more than one answer, you receive 0 points.

<u>Instructions for Five-Answer Multiple Choice Problems:</u>
Indicate on the answer sheet the correct answer to each question (*a, b, c, d* or *e*).
<u>Credit is awarded in the following way:</u>
- 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.

Unless otherwise stated, ignore air resistance. Assume the acceleration of gravity is g = 9.8 m/s^2 vertically downward. Assume that all fluids are ideal, and that all gases are ideal.

This diagram is relevant to the next two problems.

There are two masses involved in the figure: one is the mass, M_1, the other is the mass of the cart, M_2. Assume there is no friction. There is tension (force) T in the rope.



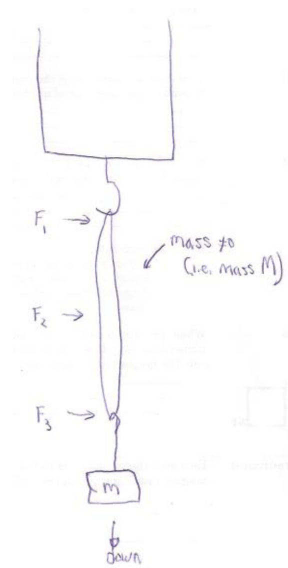
1. If $M_1 < M_2$, then the cart will not move forward.

   A) True
   B) False

2. Which of the following is true about the tension, T:

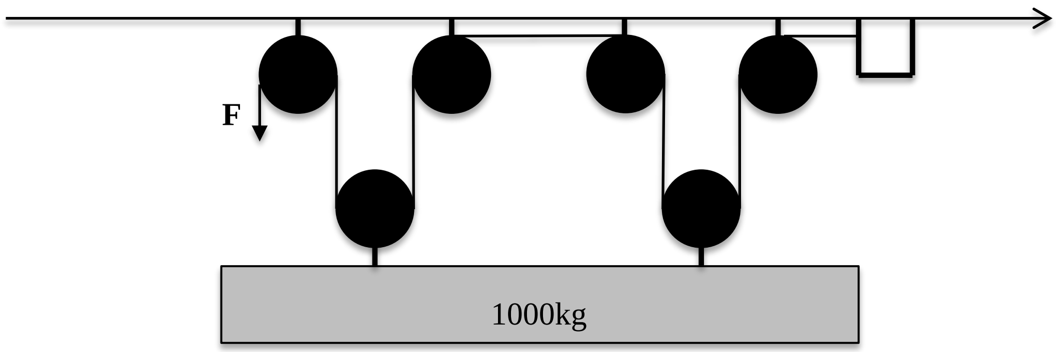
   A) T is related to M_1 and M_2.
   B) T is only related to M_1.
   C) T is only related to M_2.

3. A weight is hung on a stretchable rubber band. The rubber band has significant weight. Imagine that there is a force probe at each of the 3 points shown in the figure. The force at the 3 points (see below) are measured. Which of the following is true?



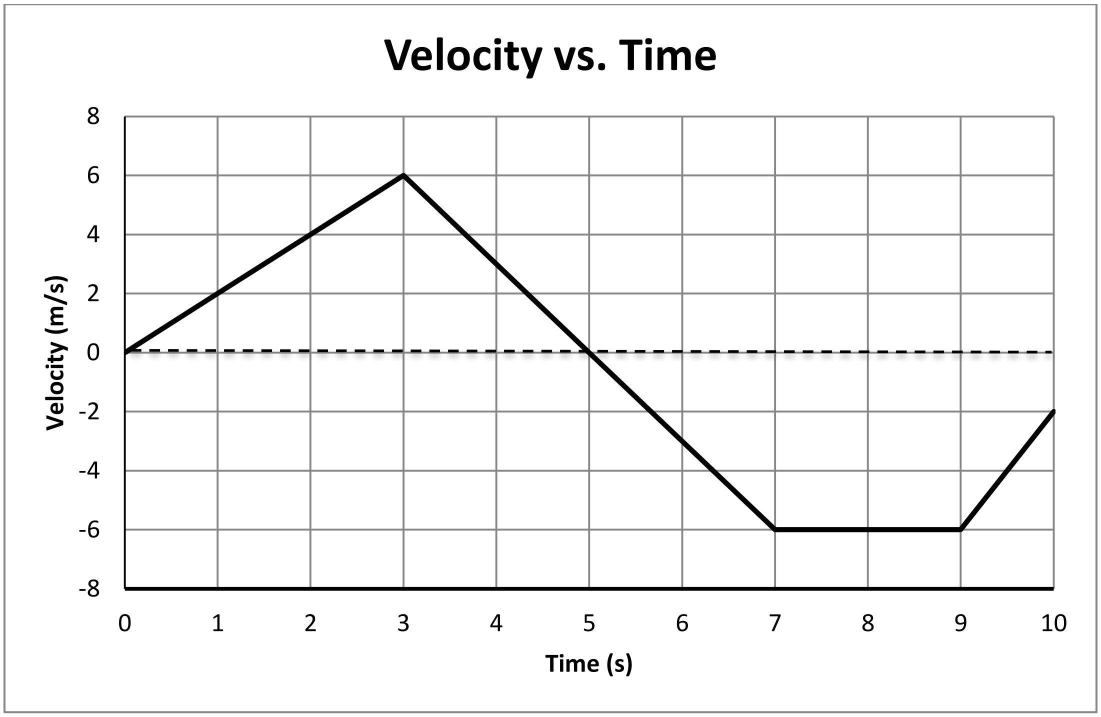
   A) $F_1 > F_2 > F_3$
   B) $F_1 < F_2 < F_3$
   C) $F_1 = F_2 = F_3$

4. The figure below shows a system of pulleys and ropes used to lift a 1000kg beam. What is the size of the force F, on the rope, required to hold the beam up (stationary) once it has been lifted?



A) 9800N
B) 4900N
C) 2450N
D) 1960N
E) 1000 N

5. An object is located at a position of 5.0m when a clock is started. The graph below describes the velocity of the object for the next 10 seconds. Where is the object at the end of that period?



A) 0m
B) 5m
C) -2m

6. A driver is going 20 m/s. She then wants to accelerate to a final speed of 30 m/s. The acceleration takes place over a distance of 1000m. If her acceleration is constant, how long does it take for her to increase her speed?

A) 1s
B) 0.25s
C) 40s
D) 25s
E) 100s

7. You are standing on a scale in an elevator on the 10^{th} floor. Let's say you weight 750 N. The elevator cable suddenly snaps, and you start falling with the elevator. What does the scale read as you pass by the 7^{th} floor?

   A) Greater than your 750 N.
   B) 750 N
   C) Less than 750 N.

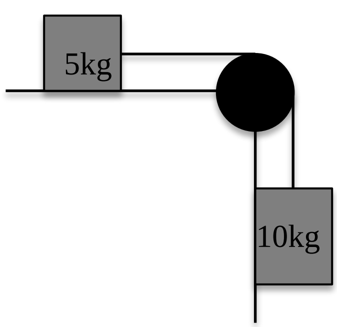
8. A person walks 6km North, 3km East, and then 2km South. How far are they from where they started?

   A) 5km
   B) 7km
   C) 11km

9. A 10.0kg box is pushed on a horizontal surface by a horizontal force of 19.6N. The acceleration of the box is $0.98 m/s^2$. What is the coefficient of kinetic friction between the box and the surface?

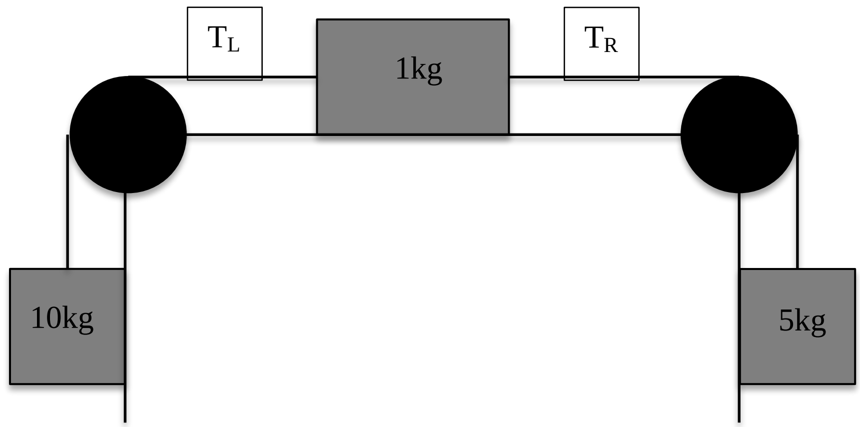
   A) 1.00
   B) 1.96
   C) 0.100
   D) 0.196
   E) 0.980

10. In the figure below, the 5 kg mass is sliding on a <u>frictionless surface</u>. The pulley is massless and frictionless. Find the tension in the string just above the 10kg block. **FIX #'s!**



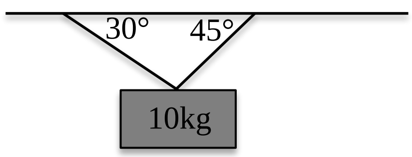
   A) 32.7N
   B) 49.0N
   C) 66.7N
   D) 98.0N
   E) 147.0N

11. In the device shown below there is no friction. You are to compare the size of the tensions in the strings to the right, T_R, and left, T_L, of the 1kg block.



A) $T_L = T_R$
B) $T_L > T_R$
C) $T_L < T_R$

12. A block, of mass 10 kg, is hanging vertically from two strings—see diagram. Find the tension in the left hand string.

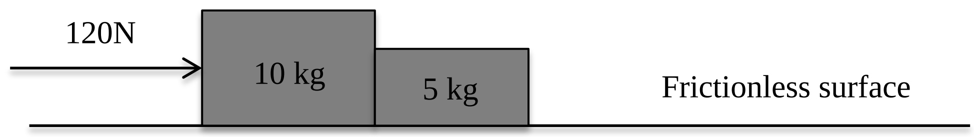


A) 35N
B) 69.3N
C) 71.7N
D) 98.0N
E) 196.0N

13. A toy tractor moves directly across a piece of paper at 0.15m/s. The paper is then pulled at 90° to this direction at a speed of 0.35m/s for 2.0s. To a stationary observer (standing to the side), how far did the tractor move during those 2.0s?

A) 0.30m
B) 0.76m
C) 1.00m

14. What is the size of the force exerted on the 5kg block by the 10kg block?



A) 120 N
B) 80 N
C) 60 N
D) 40 N
E) 0 N

The next two questions refer to the following situation

Consider two projectiles whose initial position is the same height, y = 5 m. Projectile 1 is fired horizontally with initial horizontal speed V = 10 m/s, while the Projectile 2 is held over a table with zero initial velocity.
****Make a figure.**

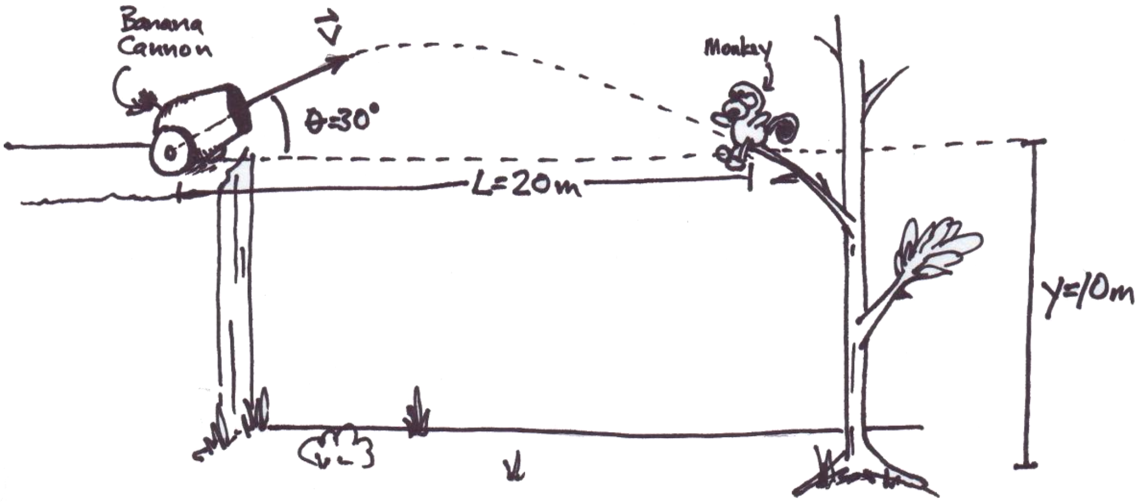
15. Which projectile strikes the ground first?

A) Projectile 1
B) Projectile 2
C) Both projectiles reach the ground simultaneously

16. How far has Projectile 1 traveled horizontally when it strikes the ground?

A) 5 m
B) 10 m
C) 15 m
D) 20 m
E) 25 m

The next two questions refer to the following diagram



A cannon, which happens to shoot out bananas, is situated at the edge of a cliff of height of y = 10 m. The cannon is aimed at an angle of θ = 30^{o} above the horizontal. It fires bananas such that it will hit a monkey sitting on a branch in a tree at an equal height. The monkey is at a horizontal distance L = 20 m away from the "banana cannon".

17. Assuming that the monkey remains stationary, what is the required speed with which the banana must be fired in order for the banana to hit the monkey? **difficulty: don't know velocity. Change to give them the velocity and ask total time of flight. Does it actually end up hitting the monkey?...

A) 7 m/s
B) 13 m/s
C) 15 m/s
D) 20 m/s
E) 25 m/s

18. Now the monkey starts to fall exactly when the cannon is fired. If we wish the monkey to catch the banana while falling, where should we aim the cannon?

A) Above the monkey ($\theta > 0$)
B) Directly at the monkey ($\theta = 0$)
C) Below the monkey ($\theta < 0$)

19. A merry-go-round of radius R = 1.5 m is spinning with angular speed ω = 1 revolution per second. What is the linear speed of a child at the edge of the merry-go-round? (1 revolution = 2π radians; π = 3.14) ** Put in a diagram**

A) 4.7 m/s
B) 9.4 m/s
C) 19 m/s

20. Another child runs up and pushes along the edge of the merry-go-round for 5 s to increase its angular speed to 2 revolutions per second. What is the angular acceleration (1 revolution = 2π radians; π = 3.14)?

A) 1.3 rad/s^2
B) 2.6 rad/s^2
C) 5.0 rad/s^2

21. While driving a car, you crest a steep hill which, at its peak, has a radius of R = 40 m. What is your maximum possible speed without losing contact with the road? **Tom will put in figure.** In diagram, make sure it's a circle showing radius.

A) 10 m/s
B) 14 m/s
C) 20 m/s
D) 28 m/s
E) 392 m/s

22. Your friend next attempts to make a 90^o left hand turn on a level road by turning in a circular arc of radius 60 m. The relevant coefficient of friction between the tires and the road is μ = 1.00. What is the maximum possible speed to successfully complete the turn?

A) 10 m/s
B) 20 m/s
C) 24 m/s
D) 400 m/s
E) 590 m/s

23. If your friend attempts to take the turn at twice the maximum speed in the above problem, what would be the required radius of the turn, R'?

A) $R' = R$
B) $R' = R/2$
C) $R' = 2R$
D) $R' = R/4$
E) $R' = 4R$

The next two questions relate to the following situation:

The orbital period of the Moon is T = 27 days, and its distance from the Earth is R = 384,000 km. Assume that the mass of the Earth is much, much greater than that of the Moon; the Earth will therefore be at the center of the Moon's circular orbit.

24. What is the Moon's linear speed?

A) 160 m/s
B) 1,000 m/s
C) 14×10^{6} m/s

25. Using this information, what is the mass of the Earth? $G = 6.673 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$

A) 6.0×10^{21} kg
B) 1.5×10^{23} kg
C) 6.2×10^{24} kg
D) 8.1×10^{25} kg
E) 1.1×10^{33} kg

Check to make sure you bubbled in all your answers.
Did you bubble in your name, exam version and network-ID?

Physics 101 Formulas

Kinematics

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

$v = v_0 + at$ $x = x_0 + v_0 t + {}^1/_2 at^2$ $v^2 = v_0^2 + 2a\Delta x$

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

Dynamics

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

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

$f_k = \mu_k F_N$ $a_c = v^2 / R = \omega^2 R$

Work & Energy

$W_F = FS\cos(\theta)$ K(or KE) $= {}^1/_2 mv^2$ $W_{NET} = \Delta K = K_f - K_i$ $E = K + U$

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

$W_{grav} = -mg\Delta y$ U_{grav} (or PE_{grav}) $= mgy$

Impulse & Momentum

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

$\Sigma\mathbf{F}_{ext}\Delta t = \Delta\mathbf{P}_{total} = \mathbf{P}_{total,final} - \mathbf{P}_{total,initial}$ (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

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

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

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)

$I = {}^1/_2 MR^2$ (solid disk or cylinder) $I = {}^2/_5 MR^2$ (solid sphere) $I = {}^2/_3 MR^2$ (hollow sphere)

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

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

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

$K_{rot} = {}^1/_2 I\omega^2 = L^2/2I$ $K_{total} = K_{trans} + K_{rot} = {}^1/_2 mv^2 + {}^1/_2 I\omega^2$

Simple Harmonic Motion

Hooke's Law: $F_s = -kx$

$W_{spring} = {}^1/_2 kx_i^2 - {}^1/_2 kx_f^2$ $U_{spring} = {}^1/_2 kx^2$

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

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

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

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

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

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

Fluids

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

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

Flow rate $Q = v_1A_1 = v_2A_2$ continuity equation (area of circle $A = \pi r^2$)

$P_1 + {}^1/_2\rho v_1^2 + \rho gy_1 = P_2 + {}^1/_2\rho v_2^2 + \rho gy_2$ 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

$Q = L_fM$ latent heat of fusion (solid to liquid) $Q = L_vM$ latent heat of vaporization

$Q = kA\Delta Tt/L$ conduction

$Q = e\sigma T^4At$ 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 = 12.000u

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

$KE_{ave} = {}^3/_2k_BT = {}^1/_2mv_{rms}^2$ $U = {}^3/_2Nk_BT$ (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)

$Q_H = Q_C + W$ (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)