Name= **Studio Day/Time=**

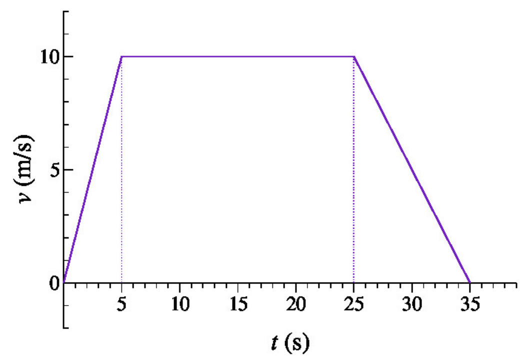
Eng. Phys. I **Final Exam - Mechanics & Thermodynamics** **Dec. 16, 2021**

Write **neat** & **clear** work. Show **formulas** used, essential steps, results with correct **units** and **significant figures**. Points shown in parenthesis. For TF and MC, choose the *best* answer. Use $g = 9.80$ m/s^2.

1. (2) **T** **F** While a car moving southward is stopping, its acceleration vector points north.

2. (2) **T** **F** For a complete lap, the average velocity of a car on a closed track is zero.

3. (20) A 62-kg runner starts at the origin at time $t = 0$ on a straight level road and runs with the velocity as a function of time shown here.



a) (8) From $t = 0$ to $t = 35$ seconds, how far did the runner go?

b) (6) What was the runner's average speed over the 35 seconds?

c) (6) For the first 5.0 seconds, what was the average net force acting on the runner?

4. (3) A system of masses obeys the Law of Conservation of Momentum only when:

a. The masses never touch each other. b. The masses are only affected by gravity.
c. There are no external forces on the masses. d. The masses stick together when colliding.

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5. (3) An object is moving at constant speed along a straight line. The strongest conclusion you can draw is:

a. The net force on the object is zero. b. There are no forces acting on the object.
c. There is at least one force acting on the object. d. The object comes from outer space.

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6. (14) A 95-kg KSU graduate celebrates by jumping from a bridge 340 m above the river below, using a parachute. He hits the water traveling at 24 km/hour. How much work did the drag force on the parachute do, in joules?

7. (4) A block of mass m is at rest on a slope inclined at $\theta = 25°$ relative to horizontal. The coefficient of static friction between the mass and the slope must satisfy:

a. $\mu_s = \sin\theta$. b. $\mu_s = \cos\theta$. c. $\mu_s = \tan\theta$. d. $\mu_s < \tan\theta$. e. $\mu_s > \tan\theta$.

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8. (14) A 0.54-kg ball is dropped from the top of a building and hits the sidewalk below with a speed of 25 m/s. After being in contact with the sidewalk for 65 ms, it bounces upward going 21 m/s.

a) (6) Draw a free body diagram of the ball when in contact with the ground, and label all the forces acting on it.

b) (8) Calculate the average force that the sidewalk exerted on the ball while they were in contact.

9. (2) **T F** The gravitational force on a mass m placed anywhere inside a spherical shell of mass M is zero.

10. (2) **T F** For satellites in circular orbits around Earth, the speed is inversely proportional to the orbital radius.

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11. (4) Planet X has a radius twice as large as Earth's, and a mass twice as large as Earth's. If you visit, your weight on its surface will be what factor times your weight on Earth?

a. 1/4. b. 1/2. c. 1. d. 2. e. 4.

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12. (14) The rocket club launches a small rocket of mass m on a vertical trajectory, that reaches a maximum *altitude* of 2 times Earth's radius R_E, before falling straight back to Earth. Find a formula that gives the launch speed in terms of Earth's escape speed $v_e = \sqrt{2GM/R_E}$.

13. (12) Bob tries to drive a 1450-kg car at a constant speed of 120 km/hour around an unbanked curve of radius $r = 175$ m. The coefficients of static and kinetic friction between tires and road are $\mu_s = 0.882$ and $\mu_k = 0.575$. Calculate the total frictional force on all four tires of the car. (Hint: Does the car skid out, or not?)

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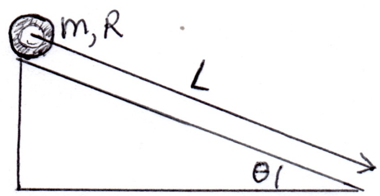
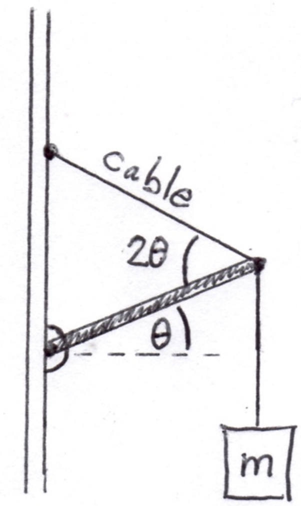
14. (14) Starting from rest, a $m = 36$ kg wheel rolls $L = 25$ m without slipping down a $\theta = 12.0°$ slope. The rotational inertia of the wheel around its center is $I_0 = 0.25mR^2$, where R is its outer radius. Find its final speed at the bottom of the slope.



15. (12) A uniform boom of length L weighing 220 N is attached by a hinge to a wall and positioned at angle $\theta = 25.0°$ above the horizontal. It is used to hang a mass m weighing 380 N as shown, with cables of negligible mass. Calculate the tension T_c in the upper cable.



16. (12) A 3.2-gram cello string is 0.84 m long with the tension adjusted to 125 N. Determine the fundamental vibrational frequency.

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17. (12) If a nurse measures the diastolic blood pressure (heart resting) at your heart to be 62 mm Hg, what would the blood pressure be at the top of your head, 54 cm higher, in mm Hg? The density of blood is 1050 kg/m^3.

18. (4) In which of the following processes does the system have a positive heat exchange Q? Check all that apply.

a. water freezes. b. ice melts. c. liquid N_2 boils. d. copper cools 10°C. e. red-hot iron emits radiation.

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19. (16) A sample of gas within a volume of 22.4 L at 0°C contains 1.0 mole each of He, N_2, O_2, and CO_2. Treat them as ideal gases.

a) (4) Which type of gas atoms/molecules has the slowest root-mean-square speed?

a. He b. N_2 c. O_2 d. CO_2 e. all tie.

b) (4) Which type of gas atoms/molecules contains the least internal energy?

a. He b. N_2 c. O_2 d. CO_2 e. all tie.

c) (4) Which type of gas atoms/molecules has the highest partial pressure?

a. He b. N_2 c. O_2 d. CO_2 e. all tie.

d) (4) What is the total pressure in the container?

a. 1.0 atm b. 2.0 atm c. 3.0 atm d. 4.0 atm e. something else.

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20. (4) In which of the following processes does the system do a positive work? Check all that apply.

a. gas absorbs heat isochorically. b. gas loses heat isochorically. c. gas expands isobarically.
d. gas is compressed isobarically. e. gas is compressed isothermally. f. gas is compressed adiabatically.

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21. (4) In which of the following processes does the system have no change in entropy? Check all that apply.

a. gas absorbs heat isochorically. b. gas loses heat isochorically. c. gas expands isobarically.
d. gas is compressed isobarically. e. gas is compressed isothermally. f. gas is compressed adiabatically.

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22. (14) The heat of fusion for water is 334 kJ/kg, and its heat capacity is 4.186 kJ/(kg·K). Find the entropy change of a 1.00-kg block of ice initially at 0°C that is thrown into ocean water at 30.0°C and eventually melts and heats up to form water at 30.0°C.

23. (12) A 0.357 mole sample of ideal diatomic gas expands isobarically at 1.00 atm from 8.00 L to 12.00 L.

a) (6) Calculate the work done by the gas, in joules.

b) (6) Calculate the heat absorbed by the gas, in joules.

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24. (12) A Carnot heat engine absorbs heat at a rate of 125 kW from a high temperature reservoir at 1250°C and exhausts heat to a low temperature reservoir at 120°C. Calculate the mechanical power output.

Score = ______________/212.

Prefixes

z=10^{-21},	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},	E=10^{18},	Z=10^{21}
zepto,	atto,	femto,	pico,	nano,	micro,	milli,	centi,	kilo,	mega,	giga,	tera,	peta,	exa,	zeta.

Physical Constants

$g = 9.80$ m/s^2 (gravitational acceleration)
$G = 6.67 \times 10^{-11}$ N·m^2/kg^2 (gravitational constant)
$M_E = 5.98 \times 10^{24}$ kg (mass of Earth)
$R_E = 6380$ km (mean radius of Earth)
$m_e = 9.11 \times 10^{-31}$ kg (electron mass)
$m_p = 1.67 \times 10^{-27}$ kg (proton mass)
$c = 299\ 792\ 458$ m/s (speed of light)
$\sigma = 5.67 \times 10^{-8}$ W/m^2·K^4 (Stefan-Boltzmann constant)
u $= 1.6605402 \times 10^{-27}$ kg (atomic mass unit)
$N_A = 6.02214 \times 10^{23}$/mol (Avogadro's number)
$k_{\rm B} = 1.3806 \times 10^{-23}$ J/K (Boltzmann's constant)
$R = k_B N_A = 8.31446\ \frac{\rm J}{\rm mol\cdot K} = 0.082057\ \frac{\rm L\cdot atm}{\rm mol\cdot K}$ (gas constant)

Units & Conversions

1 inch = 1 in = 2.54 cm
1 foot = 1 ft = 12 in = 0.3048 m
1 mile = 5280 ft =1760 yards
1 mile = 1609.344 m = 1.609344 km
1 m/s = 3.6 km/hour
88 ft/s = 60 mile/hour
1 acre = (1 mile)^2/640 = 43 560 ft^2
1 hectare = (100 m)^2 = 10^4 m^2
1 cal = 4.186 J
1 lb = 4.45 N
1 N = 0.225 lb
1 J = 1 joule = 1 N·m

symbol	element	atomic number	mass number
H	hydrogen	1	1.00794
He	helium	2	4.00260
C	carbon	6	12.0107
N	nitrogen	7	14.0067
O	oxygen	8	15.9994
Ne	neon	10	20.180
Ar	argon	18	39.948
Fe	iron	26	55.845
Ni	nickel	28	58.693
Cu	copper	29	63.546
Au	gold	79	196.97
U	uranium	92	238.03

Mass numbers are atomic masses in units of u = 1.6605×10^{-27} kg, or, molar masses for the element (1 mole = 6.022×10^{23} atoms), measured in grams. ($N_A \times 1$ u = 1 gram).

Geometry

Triangles: $A = \frac{1}{2}bh$, Circles; $C = 2\pi r$, $A = \pi r^2$, arc $= s = r\theta$. Spheres: $A = 4\pi r^2$, $V = \frac{4\pi}{3} r^3$

Trigonometry

$\sin\theta = \frac{\rm (opp)}{\rm (hyp)}$, $\cos\theta = \frac{\rm (adj)}{\rm (hyp)}$, $\tan\theta = \frac{\rm (opp)}{\rm (adj)}$.

$({\rm opp})^2 + ({\rm adj})^2 = ({\rm hyp})^2$, $a^2 + b^2 - 2ab\cos\gamma = c^2$, $\frac{\sin\alpha}{a} = \frac{\sin\beta}{b} = \frac{\sin\gamma}{c}$.

Chapter 1 - Measurements

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

Chapter 2 - Vectors - Magnitude & Direction

2D Vectors:	$\vec{\mathbf{a}} = a_x \hat{\mathbf{i}} + a_y \hat{\mathbf{j}}$,	magnitude = $a = \sqrt{a_x^2 + a_y^2}$,	direction → $\tan\theta = a_y/a_x$.
Components:	$a_x = a\cos\theta$,	$a_y = a\sin\theta$,	θ=angle to $+x$-axis.
Addition:	$\vec{\mathbf{a}} + \vec{\mathbf{b}}$, head to tail.	Subtraction: $\vec{\mathbf{a}} - \vec{\mathbf{b}}$ is $\vec{\mathbf{a}} + (-\vec{\mathbf{b}})$,	$-\vec{\mathbf{b}}$ is $\vec{\mathbf{b}}$ reversed.
Scalar product:	$\vec{\mathbf{a}} \cdot \vec{\mathbf{b}} = ab\cos\phi$,	$\vec{\mathbf{a}} \cdot \vec{\mathbf{b}} = a_x b_x + a_y b_y + a_z b_z$,	$\hat{\mathbf{i}} \cdot \hat{\mathbf{i}} = 1$, $\hat{\mathbf{i}} \cdot \hat{\mathbf{j}} = 0$, etc.
Cross product:	$\lvert\vec{\mathbf{a}} \times \vec{\mathbf{b}}\rvert = ab\sin\phi$,	$\hat{\mathbf{i}} \times \hat{\mathbf{j}} = \hat{\mathbf{k}}$, etc.	$\hat{\mathbf{i}} \times \hat{\mathbf{i}} = \hat{\mathbf{j}} \times \hat{\mathbf{j}} = \hat{\mathbf{k}} \times \hat{\mathbf{k}} = 0$.

Chapter 3 - 1D Kinematics - Straight-line motion

Velocity:	$v_{\rm ave} = \frac{\Delta x}{\Delta t}$,	$\Delta x = x - x_0$,	$v(t) = \frac{dx}{dt}$= slope of $x(t)$.
Acceleration:	$a_{\rm ave} = \frac{\Delta v}{\Delta t}$,	$\Delta v = v - v_0$,	$a(t) = \frac{dv}{dt}$= slope of $v(t)$.
Constant acceleration:	$v = v_0 + at$,	$v_{\rm ave} = \frac{1}{2}(v_0 + v)$.	
	$x = x_0 + v_0 t + \frac{1}{2}at^2$.	$x = x_0 + v_{\rm ave}t$,	$v^2 = v_0^2 + 2a\Delta x$.
Free fall ($+y$-axis is up):	$y = y_0 + v_{0y}t - \frac{1}{2}gt^2$,	$v_y = v_{0y} - gt$,	$v_y^2 = v_{0y}^2 - 2g\Delta y$.

Chapter 4 - 2D and 3D Motion - Vector displacement, velocity, acceleration

Position:	$\vec{\mathbf{r}} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}}$,	$\vec{\mathbf{r}} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} + z\hat{\mathbf{k}}$.	$\vec{\mathbf{r}} = (x, y, z)$.
Velocity:	$\vec{\mathbf{v}}_{\text{ave}} = \frac{\Delta\vec{\mathbf{r}}}{\Delta t}$,	$\vec{\mathbf{v}} = \frac{d\vec{\mathbf{r}}}{dt}$,	$\Delta\vec{\mathbf{r}} = \vec{\mathbf{r}} - \vec{\mathbf{r}}_0$.
Acceleration:	$\vec{\mathbf{a}}_{\text{ave}} = \frac{\Delta\vec{\mathbf{v}}}{\Delta t}$,	$\vec{\mathbf{a}} = \frac{d\vec{\mathbf{v}}}{dt}$,	$\Delta\vec{\mathbf{v}} = \vec{\mathbf{v}} - \vec{\mathbf{v}}_0$.

Chapter 5 - Newton's laws and forces

Newton's 1st Law:	$\vec{a} = \frac{d\vec{v}}{dt} = 0$ unless $\vec{F}_{\text{net}} \neq 0$,	$\vec{F}_{\text{net}} = \sum \vec{F}_i$ = sum of all forces on a mass.
Newton's 2nd Law:	$\vec{F}_{\text{net}} = m\vec{a}$,	$F_{\text{net},x} = ma_x,\ F_{\text{net},y} = ma_y,\ F_{\text{net},z} = ma_z$.
Newton's 3rd Law:	$\vec{F}_{AB} = -\vec{F}_{BA}$,	Forces exist in action-reaction pairs.
Gravitational force near Earth:	$F_G = mg$, downward.	Apparent weight is force measured by a scales.
Gravity components on inclines:	$F_\parallel = mg\sin\theta,\ F_\perp = mg\cos\theta$,	← for incline at angle θ to horizontal.
Spring force:	$F_s = -kx$,	x is the displacement from equilibrium.

Chapter 6 - Friction, circular motion

Static friction (object is stuck):	$f_s \leq \mu_s N$,	Can balance other forces in any direction.
Kinetic friction (object sliding):	$f_k = \mu_k N$,	Acts **against** the relative motion of surfaces.
Centripetal acceleration:	$a_c = \frac{v^2}{r}$,	Points towards the center of the circle.
Rates of circular motion:	speed $v = \frac{2\pi r}{T} = 2\pi r f$,	frequency $f = \frac{1}{T}$, T=period of one revolution.

Chapter 7 - Work and kinetic energy

Work done by a force:	$dW = \vec{\mathbf{F}} \cdot d\vec{\mathbf{r}} = F\ dr\ \cos\theta$,	$W_{AB} = \int_A^B \vec{\mathbf{F}} \cdot d\vec{\mathbf{r}}$ (along the path $A \to B$).
Examples:	$W = \vec{\mathbf{F}} \cdot \Delta\vec{\mathbf{r}}$ (constant $\mathbf{F}$),	$W_s = -\frac{1}{2}k(x_B^2 - x_A^2)$ (spring $F = -kx$).
Work-KE theorem, power:	$\Delta\text{KE} = W_{\text{net}}$ = all works on m.	$\text{KE} = \frac{1}{2}mv^2$, $P = \frac{dW}{dt}$, $P_{\text{ave}} = \frac{\Delta W}{\Delta t}$.

Chapter 8 - Potential energy and Conservation of energy

PE for gravity:	$\Delta U = mg\Delta y$,	$U(y) = mgy+$ constant,	←(near Earth' surface).
PE for springs:	$\Delta U = \frac{1}{2}k(x_B^2 - x_A^2)$,	$U(x) = \frac{1}{2}kx^2$ + constant.	
Any arbitrary system:	$\Delta E_{\text{mec}} = W_{\text{nc}}$	$E_{\text{tot}} = E_{\text{mec}} + E_{\text{thermal}} + E_{\text{other}}$,	$\Delta E_{\text{tot}} = 0$.

Chapter 9 - Linear momentum and collisions

Linear Momentum:	$\vec{\mathbf{p}} = m\vec{\mathbf{v}}$,	Impulse Theorem:	$\Delta\vec{\mathbf{p}} = \vec{\mathbf{J}} = \int \vec{\mathbf{F}}(t)\,dt = \vec{\mathbf{F}}_{\text{ave}}\Delta t$.
Instantaneous force:	$\vec{\mathbf{F}} = \frac{d\vec{\mathbf{p}}}{dt}$,	Average force:	$\vec{\mathbf{F}}_{\text{ave}} = \frac{\Delta\vec{\mathbf{p}}}{\Delta t}$.
Conservation (@ $\vec{\mathbf{F}}_{\text{net}} = 0$):	$\Delta\vec{\mathbf{p}}_{\text{total}} = 0$,	$\vec{\mathbf{p}}_{1\text{i}} + \vec{\mathbf{p}}_{2\text{i}} = \vec{\mathbf{p}}_{1\text{f}} + \vec{\mathbf{p}}_{2\text{f}}$,	i=initial, f=final.

Center of mass:	$\vec{\mathbf{r}}_{\text{com}} = \frac{m_1\vec{\mathbf{r}}_1 + m_2\vec{\mathbf{r}}_2 + \ldots}{m_1 + m_2 + \ldots}$,	$\vec{\mathbf{v}}_{\text{com}} = \frac{m_1\vec{\mathbf{v}}_1 + m_2\vec{\mathbf{v}}_2 + \ldots}{m_1 + m_2 + \ldots}$	
1D elastic collisions:	$v_{1\text{f}} = 2v_{\text{com}} - v_{1\text{i}}$	$v_{2\text{f}} = 2v_{\text{com}} - v_{2\text{i}}$,	Equal masses swap velocities.
Other collisions:	$\vec{P}_{\text{total}} = M\vec{\mathbf{v}}_{\text{com}}$ = const.	$\vec{P}_{\text{total}} = m_1\vec{\mathbf{v}}_1 + m_2\vec{\mathbf{v}}_2$ = const.	

Chapters 10 - Rotational motion

Coordinates:	1 rev = 2π rad	1 rev = 360°,	$\omega = 2\pi f$,	$f = \frac{1}{T}$.
Averages:	$\omega_{\text{ave}} = \frac{\Delta\theta}{\Delta t}$,	$\Delta\theta = \omega_{\text{ave}}\Delta t$,	$\alpha_{\text{ave}} = \frac{\Delta\omega}{\Delta t}$,	$\Delta\omega = \alpha_{\text{ave}}\Delta t$.
Radius factors:	$l = \theta r$,	$v = \omega r$,	$a_{\tan} = \alpha r$,	$a_c = \omega^2 r$.
Const. acceleration:	$\omega = \omega_0 + \alpha t$,	$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$,	$\omega_{\text{ave}} = \frac{1}{2}(\omega_0 + \omega)$,	$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$.

Torque:	$\vec{\tau} = \vec{\mathbf{r}} \times \vec{\mathbf{F}}$,	$\tau = rF\sin\theta$,	$\tau = r_\perp F = rF_\perp$,	$\hat{\mathbf{i}} \times \hat{\mathbf{j}} = \hat{\mathbf{k}}$, etc.	
Dynamics, inertia:	$I = \Sigma m r^2$,	$I = \int dm\, r^2$,	$\tau_{\text{net}} = I\alpha$,	$K_{\text{rot}} = \frac{1}{2}I\omega^2$.	
Rotational inertias:	$I_0 = MR^2$,	$I_0 = \frac{1}{2}MR^2$,	$I_0 = \frac{2}{5}MR^2$,	$I_0 = \frac{1}{12}ML^2$,	$I = I_0 + md^2$.
(about centers)	thin hoop,	solid cylinder,	solid sphere,	thin rod,	↑ about parallel axis.
Work, power:	$dW = \tau\,d\theta$,	$W = \int \tau\,d\theta$,	$W = \tau_{\text{ave}}\Delta\theta$,	$P = \tau\omega$.	

Chapter 11 - Angular momentum

Angular momentum:	$\vec{\mathbf{l}} = \vec{\mathbf{r}} \times \vec{\mathbf{p}}$,	$l = rp\sin\theta$,	$l = r_\perp p = rp_\perp$,	$\vec{\mathbf{L}} = \int \vec{\mathbf{r}} \times \vec{\mathbf{v}}\,dm$,	$L = I\omega$.
Dynamics:	$\frac{d}{dt}\vec{\mathbf{L}} = \vec{\tau}_{\text{net}}$,	$\Delta\vec{\mathbf{L}} = \vec{\tau}_{\text{ave}}\Delta t$,	conservation→	$\vec{\mathbf{L}}_{\text{total}}$ =const.	←(@ $\vec{\tau}_{\text{net}} = 0$).

Chapter 12 - Static equilibrium

Statics requirements:	$\sum F_x = \sum F_y = \sum F_z = 0$,	$\sum \tau = 0$,	$\tau = rF\sin\theta$.
Stress & strain:	stress = $F_\perp/A$,	strain = $\Delta L/L_0$,	stress = $Y\times$ strain.
Shear forces:	stress = $F_\parallel/A$,	strain = $\Delta x/L_0$,	stress = $S\times$ strain.

Chapter 13 - Gravitation

Gravitational force:	$F = Gm_1m_2/r^2$,	$F = mg$,	$g = GM/r^2$,	$v_{\text{escape}} = \sqrt{2GM/R}$.
Gravitational PE:	$U = -Gm_1m_2/r$,	$\Delta U + \Delta K = 0$,	Kepler's orbits:	$T^2 = \frac{4\pi^2}{GM}r^3$.

Chapter 15 - Oscillations

Oscillations:	$x = A\cos(\omega t + \phi)$,	$v = -\omega A\sin(\omega t + \phi)$,	$a = -\omega^2 x$,	$\omega = 2\pi f = \frac{2\pi}{T}$.
Mass on a spring:	$F = -kx = ma$,	$\omega = \sqrt{k/m}$.		
Torsion oscillator:	$\tau = -\kappa\theta = I\alpha$,	$\omega = \sqrt{\kappa/I}$.		
Pendula:	$\tau = -mgL\theta = I\alpha$,	$\omega = \sqrt{g/L}$ (simple),	$\omega = \sqrt{mgL/I}$ (physical).	
Energy:	$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$,	$E = \frac{1}{2}kA^2$,	$E = \frac{1}{2}mv_{\max}^2$,	$v_{\max} = \omega A$.

Chapter 16 - Waves

Traveling waves:	$\lambda = vT$,	$v = f\lambda$,	$v = \sqrt{\frac{F_T}{\mu}}$,	$\mu = m/L$ (strings).
Wave number, speed:	$k = 2\pi/\lambda$,	$\omega = 2\pi/T$,	$v = \omega/k$,	$y(x,t) = A\sin(kx - \omega t + \phi)$.
Intensity, power:	$I = P/A$,	$I = P/4\pi r^2$,	$P = E_\lambda/T$,	$P = \frac{1}{2}\mu A^2\omega^2 v$.
Standing waves:	node-to-node $= \lambda/2$.			

Chapter 17 - Sound

Speed of sound:	$v = \sqrt{B/\rho}$ (fluids),	$v = \sqrt{Y/\rho}$ (solids),	$v = \sqrt{\gamma RT/M_A}$ (ideal gas).
Speed in air:	$v = (331\text{m/s})\sqrt{1 + T_C/273°\text{C}}$,	$v(0°\text{C}) = 331$ m/s,	$v(20°\text{C}) = 343$ m/s.
Intensity I:	$I = P/A$,	$I = P/4\pi r^2$.	
Sound level β:	$\beta = (10\text{ dB})\log\frac{I}{I_0}$,	$I = I_0\ 10^{\beta/(10\text{ dB})}$,	$I_0 = 10^{-12}$ W/m^2 (threshold).
Standing waves:	nodes @ ends of strings,	nodes @ ends of closed tubes,	antinodes @ ends of open tubes.
Doppler shift:	$f_O = f_S\frac{v+v_O}{v+v_S}$ (use x-comps.),	v=sound, O at origin,	v_O=observer, v_S=source.

Chapter 14 - Fluids

1 atmosphere = 1 atm = 101.3 kPa = 1.013 bar = 760 torr = 760 mm Hg = 14.7 lb/in^2.

Units:	1 Pa = 1 N/m^2,	1 bar = 10^5 Pa,	1 mm Hg = 133.3 Pa.
Density:	$\rho = m/V$,	$\rho_{H_2O} = 10^3$ kg/m^3 (4°C),	10^3 kg/m^3 = 1 g/cm^3.
Pressure:	$p = F/A$,	$p_2 = p_1 + \rho g d$,	$p_{\text{abs}} = p_{\text{atm}} + p_{\text{gauge}}$.
Archimedes:	$F_B = \rho_{\text{fluid}} g V_s$,	Bernoulli energy conserv.→	$p + \rho g y + \frac{1}{2}\rho v^2 =$ const.
Flow rates:	$Q = Av$,	$Q_m = \rho A v$,	$Q = (p_2 - p_1)\pi r^4/(8\eta L)$.
Viscosity:	$F = \eta v A/L$,	$N_R = 2\rho v r/\eta$,	$N_R < 2000$ laminar, $N_R > 3000$ turbulent.

V2 - Chapter 1 - Temperature & Heat transfer

Moles:	$n = N/N_A$,	$n = M/M_A$,	$N_A = 6.022\times10^{23}$/mol,	1 u $\times N_A$ = 1 gram.
Temperatures:	$T_C = \frac{5}{9}(T_F - 32)$,	$T_F = \frac{9}{5}T_C + 32$,	$T_K = T_C + 273.15$,	$T = \frac{p}{p_{TP}}T_{TP}$.
Expansion:	$\Delta L = \alpha L_0\Delta T$,	$\Delta A = 2\alpha A_0\Delta T$,	$\Delta V = \beta V_0\Delta T$,	$\beta = 3\alpha$ (solids).
Heat transfers:	$Q = mc\Delta T$,	$Q = mL_F$,	$Q = mL_V$,	1 cal = 4.186 J.
Heat flow:	$P = kA\Delta T/d$,	$P = \sigma e A(T_2^4 - T_1^4)$,	$P_{\text{solar}} \approx (1\text{ kW/m}^2)eA\cos\theta$.	

V2 - Chapter 2 - Kinetic theory & Ideal gases

Ideal gases:	$PV = nRT$,	$PV = Nk_BT$,	$R = 8.314\ \frac{\text{J}}{\text{mol}\cdot\text{K}}$,	$k_B = R/N_A$.
Kinetic theory:	$\overline{\text{KE}}_{\text{trans}} = \frac{m}{2}v_{\text{rms}}^2 = \frac{3}{2}k_BT$,	$v_{\text{rms}} = \sqrt{\frac{3k_BT}{m}} = \sqrt{\frac{3RT}{M_A}}$,	$m = M_A/N_A$,	m =molecule.
Internal energy:	$E_{\text{int}} = \frac{d}{2}Nk_BT$,	$E_{\text{int}} = \frac{d}{2}nRT$,	$d = 3, 5, 7$	
Molecules:	monatomic, $d = 3$,	diatomic, $d = 5$,	polyatomic, $d = 7$,	← room temp.
Specific heats:	$Q = nC\Delta T$,	$C_V = \frac{d}{2}R$,	$C_P = C_V + R$,	$\gamma \equiv C_P/C_V$.

V2 - Chapters 3,4 - 1st and 2nd Laws of Thermodynamics

Process (constant):	isobaric (p)	isothermal (T)	isochoric (V)	adiabatic (pV^γ with $Q = 0$)
1st Law:	$\Delta E_{\text{int}} = Q - W$,	$W = \int_i^f p\ dV$,	$W_{\text{isobar}} = p\ \Delta V$,	$W_{\text{isotherm}} = nRT\ln(V_f/V_i)$.
2nd Law:	$\Delta S_{\text{total}} \geq 0$,	$\Delta S \equiv \int_i^f dQ/T$,	$\Delta S = mc\ln(T_f/T_i)$,	$\Delta S = mL/T$.
Engines:	$W = Q_H - Q_L$,	$\varepsilon = W/Q_H$,	Carnot: $\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$,	$P_{\text{mech}} = W/t$.
AC, heat pumps:	$K_{AC} = Q_L/W$,	$P_{\text{cool}} = Q_L/t$,	$K_{HP} = Q_H/W$,	$P_{\text{heat}} = Q_H/t$.