Physics 2053C – Fall 2001

Review for Final Exam

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Important Topics

- Kinematics
- Forces/Newton's Laws
- Energy/Momentum Conservation
- Ideal Gases/Heat

Variable/Quantity/Units

t	time	s
x	distance	m
v	velocity	m/s
a	acceleration	m/s^2
F	force	$N = kg \cdot m/s^2$
E	energy	$J = N \cdot m$
P	power	$W = J \cdot s$

Kinematics

- Position
- Velocity – rate of change of position
- Acceleration – rate of change of velocity
  - Constant acceleration
  - Constant velocity $a = 0$
  - Constant position $v = 0, a = 0$

Equations of Motion

$$x = x_0 + v_0 t + \tfrac{1}{2} a t^2$$
$$v = v_0 + at$$
$$v^2 = v_0^2 + 2a(x - x_0)$$

x = position
x_0 = initial position
v = velocity
v_0 = initial velocity
a = acceleration
t = time

Forces

- Force due to gravity
- Normal force
- Force due to friction
- Tension
- Buoyancy
- External force (e.g. a push)

Gravity

- acceleration due to gravity ($g = 9.80\ m/s^2$)
- force due to gravity $F = mg$ ← Newtons
- Weight = force due to gravity
- which direction???
- Also, $F = G(m_1m_2)/r^2$

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Types of Energy

- Kinetic
  - Linear — $K = \frac{1}{2}mv^2$
  - Rotational
- Potential
  - Gravitational — $U = mgh$
  - Spring — $U = \frac{1}{2}kx^2$
  - Internal Energy
- Heat — $Q = mc\Delta T$
- Work — $W = Fd\cos\theta$

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Ideal Gas Law

$$PV = nRT$$

P = pressure (atm, bar, N/m^2)
V = volume (m^3)
n = # of moles
R = gas constant
T = temperature (K)

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How to solve FORCE problems

1) Read the problem.
   (identify what you do and don't know, look for "hidden" knowledge)
2) Draw a free-body diagram
   (identify all forces acting upon object)
3) Add all forces in one direction together (x?)
   $\Sigma F = F1 + F2 + F3 + \ldots$
   (determine sum of forces, maybe $F_{net} = 0$ or $F_{net} = ma$)
4) Add all forces in other direction together (y?)
   (determine sum of forces, maybe $F_{net} = 0$ or $F_{net} = ma$)
5) Solve for what you don't know

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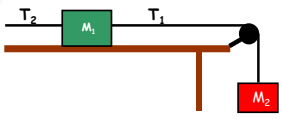
Sample Force Problem



$M_1 = 20.0$ kg
$M_2 = 10.0$ kg
$\mu = 0.3$

The boxes are not moving.

1) What is the value of T_1?
2) What is the value of T_2?

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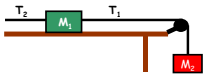
Sample Force Problem (cont)

$M_1 = 20.0$ kg
$M_2 = 10.0$ kg
$\mu = 0.3$



$\Sigma F = T_1 - F_g = 0$
$T_1 = F_g$
$T_1 = M_2g = (10.0\ kg)(9.80\ m/s^2)$
$T_1 = 98.0\ N$

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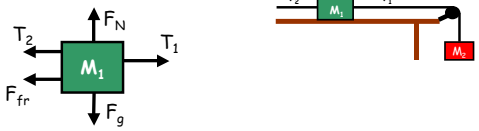
Sample Force Problem (cont)

$M_1 = 20.0$ kg
$M_2 = 10.0$ kg
$\mu = 0.3$



$\Sigma F_y = F_N - F_g = 0$

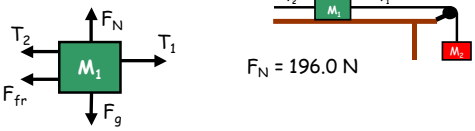
$F_N = F_g$

$F_N = M_1 g = (20.0\text{ kg})(9.80\text{ m/s}^2)$

$F_N = 196.0$ N

Sample Force Problem (cont)

$M_1 = 20.0$ kg
$M_2 = 10.0$ kg
$\mu = 0.3$



$F_N = 196.0$ N

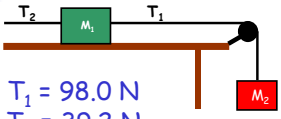
$\Sigma F_x = T_1 - T_2 - F_{fr} = 0$

$T_2 = T_1 - F_{fr}$

$T_2 = 98.0\text{ N} - (0.3)(196.0\text{ N})$

$T_2 = 39.2$ N

Sample Force Problem (cont)



$T_1 = 98.0$ N
$T_2 = 39.2$ N

$M_1 = 20.0$ kg
$M_2 = 10.0$ kg
$\mu = 0.3$

What if the boxes are moving with constant velocity?
What if the boxes are accelerating at $a = 2.2\text{ m/s}^2$?
What if we remove T_2?

How to Solve ENERGY Problems

1) Identify types of energy
   - Kinetic?
   - Gravitational Potential?
   - Spring Potential?
   - Heat?
   - Internal Energy?
   - Work?
2) Identify initial and final conditions
3) Find unknown quantities:

$W = \Delta K + \Delta U$ (if $W \neq 0$)

$K_i + U_i = K_f + U_f$ (if $W = 0$)

Sample Energy Problem

A 25 kg block is released from rest 5.5 m up a frictionless plane inclined at 30°. The block slides down the incline and along a horizontal surface. The horizontal surface has a coefficient of static friction of 0.32.

What is the velocity of the block at the bottom of the incline?

How far along the horizontal surface will the block slide?

Sample Energy Problem (cont)

What kind of energies are present?

- Kinetic energy
- Gravitational potential energy
- Work done by friction

What is the energy at A?

$E_A = KE + PE = 0 + mgh = mgd\sin\theta = (25\text{ kg})(9.80\text{ m/s}^2)(5\text{ m})(\sin 30^\circ)$

$E_A = 612.5$ J

Sample Energy Problem (cont)

What is the energy at B?

$E_B = E_A = 612.5$ J

What happens to the energy as the box goes from A to B?

What is the velocity at B?

$E_B = KE + PE = ½ mv_B^2 + 0$

$v_B = 7.0$ m/s

Sample Energy Problem (cont)

What happens to the energy as the box goes from B to C?

What is the energy at C?

$E_C = 0.0$ J

How far does the box slide?

$W = \Delta KE + \Delta PE$

$W = (0.0 \text{ J} - 612.5 \text{ J}) + 0 \text{ J}$

$W_{fr} = F_f d = \mu F_N d$

$W_{fr} = \mu mgd$

$W = W_{fr}$

$-612.5 \text{ J} = (0.32)(25 \text{ kg})(9.8 \text{ m/s}^2)d = (78.4 \text{ N})d$

$d = (612.5 \text{ J})/(78.4 \text{ N}) = 7.81$ m

How to Solve IDEAL GAS Problems

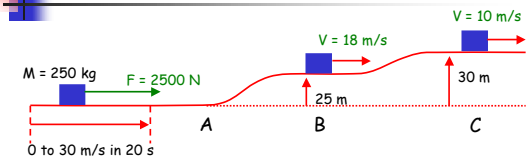
$$PV = nRT$$

1) Identify initial and final conditions
2) Take ratio

$$\frac{P_1V_1}{P_2V_2} = \frac{n_1RT_1}{n_2RT_2}$$

3) Cancel anything which is constant
4) Solve for what you don't know

Sample Problem



- What are the forces on the motorcycle as it accelerates (A)?
- What are the forces on the motorcycle as it moves at constant speed (B,C)?
- How far does it travel while accelerating from rest to 30 m/s?
- What is the kinetic energy at points A, B, C?
- How much work is done by motorcycle?
- How much work is done by friction getting to A, B, C?
- What are the forces on the object as it moves upward from A to B?