CHAPTER 8 POTENTIAL ENERGY

From chapter 1 of this course to the present, we have been studying mechanical systems. We first discussed their kinematic properties, thereby introducing the concepts of displacement, velocity and acceleration. We studied the dynamic properties of mechanical systems, introducing the ideas of force, momentum, and kinetic energy. We now need to introduce one further quantity before our study of mechanical systems will be complete. This quantity is POTENTIAL ENERGY.

Why is potential energy interesting? The answer to this question lies in the all important notion of a conservation law. We are leading up to a conservation law which is far more important and generally applicable than the momentum and kinetic energy conservation laws already studied. This is the law of the conservation of TOTAL MECHANICAL ENERGY, where the total mechanical energy of a system is defined as the sum of the potential energy and the kinetic energy.

When we have a handle on both kinetic and potential energy, we can analyze mechanical systems using a very powerful tool - the law of conservation of total mechanical energy. We have seen how kinetic energy is conserved under certain specific conditions. It turns out that the total mechanical energy, defined as the sum of the kinetic energy and potential energy of a system, is conserved in an extraordinary wide variety of circumstances. If one is careful, this conservation law can be used to analyze any mechanical system where the action of friction is of a major factor - from the motion of planets and satellites to the bone structure of an animal.

In this chapter we will first see what potential energy is and how it figures into the description of mechanical systems where forces are acting. Then we will explore the total mechanical energy of many systems in detail and why and how this quantity is conserved.

When in future chapters we leave the realm of purely mechanical phenomena to study heat, electricity, magnetism and atomic structure, we will find conservation of total energy no less applicable. In studying these different kinds of physical systems, we will have to think a bit about what constitutes the total energy of a system. But having done this, we will find that this general conservation law can be applied in the same manner as we will learn to do in this chapter.

PERFORMANCE OBJECTIVES

Upon completion of this chapter you should:

1. Be able to determine the potential energy stored in a spring.

2. Be able to equate mathematically the potential energy stored in a spring to the amount of stretch or compression the spring undergoes.

3. Be able to describe mechanical energy conservation as two objects interact elastically.

(over

4. Be able to state the relationships between the change in gravitational potential energy near the surface of the earth and the height of a mass "m" above the surface of the earth.

5. Be able to describe the energy conservation occurring in an object falling toward the earth, neglecting friction.

6. Be able to recognize the nature of potential energy and discuss gravitational potential energy in general (at any distance from the earth's surface).

7. Be able to calculate:

   a. The escape velocity of any object leaving the earth or another object.

   b. The binding energy to the earth or another object.

1. Read: Section 8-1 The Spring Bumper page 151
   Section 8-2 Energy In Simple Harmonic Motion page 154

   a. How is the compression or stretch of a spring related to the force which causes the compression or stretch?

2. Sketch a graph of F vs x for a spring.

   a. What does the area under the graph represent?

   b. What formula is used to calculate this area?

   c. For any spring, F = ______.

   d. The work done to stretch or compress a spring a distance "x" is: W = _______.

   e. What does 1/2kx^2 represent? It is represented by symbol _______.

3. Use Figure 8-1, page 152 to answer the following questions.

   a. At the beginning:

      (1). the total mechanical energy is possessed by what object?

      (2). the type of energy is _______________________.

      (3). the magnitude of the energy can be expressed as E_T = _________.

   b. In the third event from the top:

      (1). How much kinetic energy does the block possess?

      (2). How does this magnitude compare to the kinetic energy that the block possessed at the beginning?

      (3). Where is the energy that the block lost?

      (4). The potential energy stored in the spring is: U_o = _________ which is equal to ______________________.

      (5). Thus the total mechanical energy (E_T) equals the ______________ of the block plus the _________________ of the spring.

      (6). (Thus E_T = ______ + ______.

   c. In the fourth event:

      (1). All the energy is now located where?

      (2). Thus E_T = 1/2 mv_o^2 = ____________.

      (3). Therefore the amount of spring stretch or compression "x" can be calculated using the formula: x = __________.

4. Problems: page 154: #1 #2 #3
   169: #19 #22

5. Ask instructor for his stool, weights, and instructions for performing a spinning demonstration.

7. Read: Section 8-3 Potential Energy near the Surface of the Earth p-158

8. Problems: page 170: #23 #24 #25 #26

9. Request to see some bouncing spheres from your instructor.

10. Read: Section 8-4 Gravitational Potential Energy near the Surface of the Earth page 158

    a. Study Notes 1: REFERENCE POINTS OF POTENTIAL ENERGY provides further insight.

    b. When an object falls toward the earth, there is a mutual force between the object and the earth. Why can we neglect the motion of the earth and be concerned only with the falling object?

    c. The change in potential energy near the surface of the earth is calculated using the formula: U_g = ______________.

    d. Study Notes 2: GRAVITATIONAL FIELDS contains an excellent discussion as to why one can let "g" remain constant (near the surface of the earth).

11. a. An object of mass 3.0 kg is raised from the table top, (position d) to (position a) which is 8 meters above the table top. Indicate the value of the potential and kinetic energy when the object is at 'a' in the appropriate blanks at the right.

		U_g	E_k	v
8 meters	(a)	___	___	___
6 meters	(b)	___	___	___
4 meters	(c)	___	___	___
0 meters	(d)	___	___	___

    b. The object is allowed to fall. As it passes (position b and c) it possesses some potential energy and some kinetic energy. Determine the amount of each and record the information in the appropriate blanks.

    c. As the object reaches (position d), (which ia zero distance above the table, yet not touching the table), it possesses some energy. Record the values of kinetic and potential energy that the object possesses in the appropriate blanks.

d. Express the speed 'v' of the object in terms of the quantities: m, g, Δh.

e. Calculate the speed of the object as it reaches (position d) and record it.

f. Predict the speed of the object as it passes (position b and c). Then calculate the speed. Did your prediction agree with the calculations?

12. Experiment 13: CHANGES IN POTENTIAL ENERGY PAGE 25

a. Use YOUR spring from a previous experiment in which its "k" value was determined.

B. A detailed write-up is expected.

c. In the past students have wasted much time doing this experiment. To save time you should outline what you are going to do and discuss the outline with your instructor before doing the experiment.

13. Problems: page 163: #8 #9(a must) #10
page 171: #27 #29 #30 #31

14. Read: Section 8-5 Gravitational Potential Energy in General page 163

a. Ask instructor for an explanation of what was said in this section.

b. See: Study Notes 3: SIGN OF POTENTIAL ENERGY AND
Study Notes 4: SIGN OF TOTAL MECHANICAL ENERGY
which are included for your reading pleasure.

c. Why does the gravitational potential energy equal zero at infinity?

15. Read: Section 8-6 ESCAPE ENERGY AND BINDING ENERGY page 165

Note...Study Notes 5. THE SIGN OF BINDING ENERGY is included.

The following four questions represent the general outline of the chapter. If you can answer them, you should have an understanding of this section. As in the past, if you have difficulty, see your instructor.

a. What is the energy (per kg mass) needed to escape from the earth?

b. What is the velocity needed to escape from the earth?

c. What is the energy (per kg mass) needed to put an object into orbit near the surface of the earth) compared to the kinetic energy needed to escape the earth's surface.

16. Problems: page 168: #13 #14 #15 #17
page 173: #33 #34 #35 #36

17. Read: Section 8-7 Total Mechanical Energy page 168

Note...Read Study Notes 4: THE SIGN OF THE TOTAL MECHANICAL ENERGY.

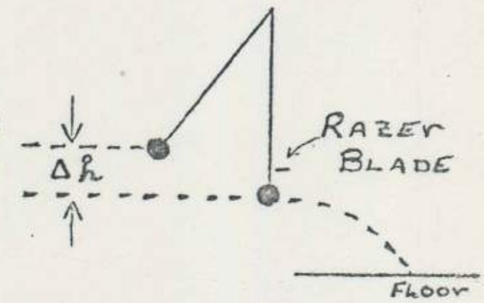
18. Optional...As time permits, you may do as many of the following three activities as you desire.

a. Determination of the speed of a BB gun.

See instructor for details.

A worksheet is available for your asking.

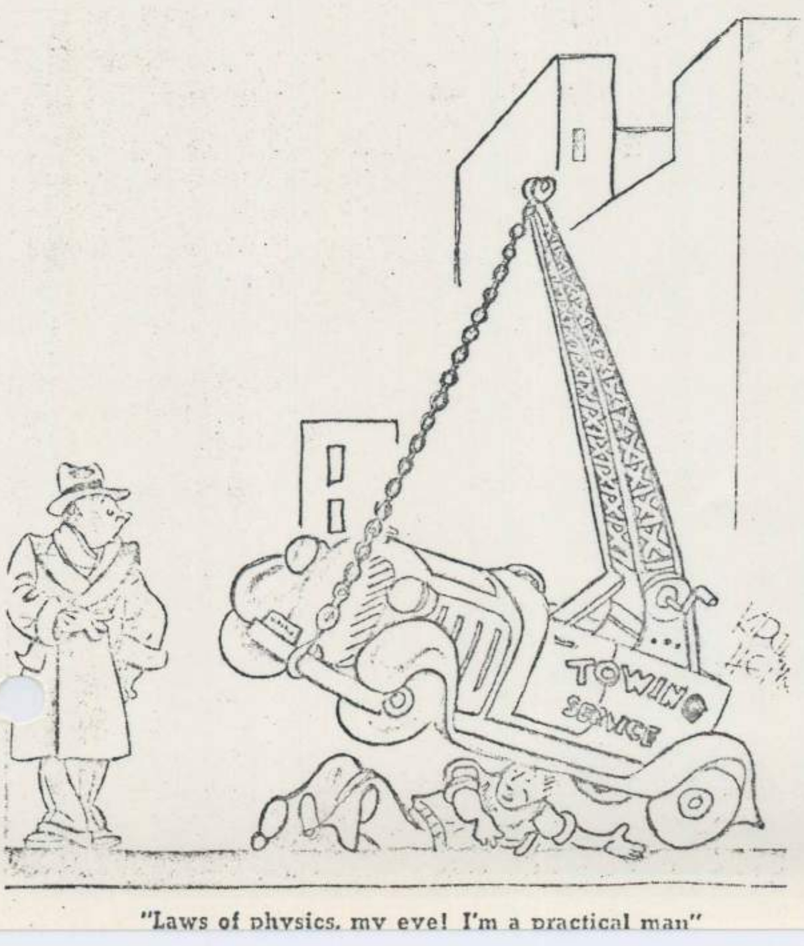
b. A mass on a string is pulled away from the vertical and raised a certain height h. The bob is released. As it reaches the vertical, a razor blade cuts the thread. Using appropriate data, calculate the speed of the mass at the instant it was cut from the string.



c. Predicting the range of a projectile.

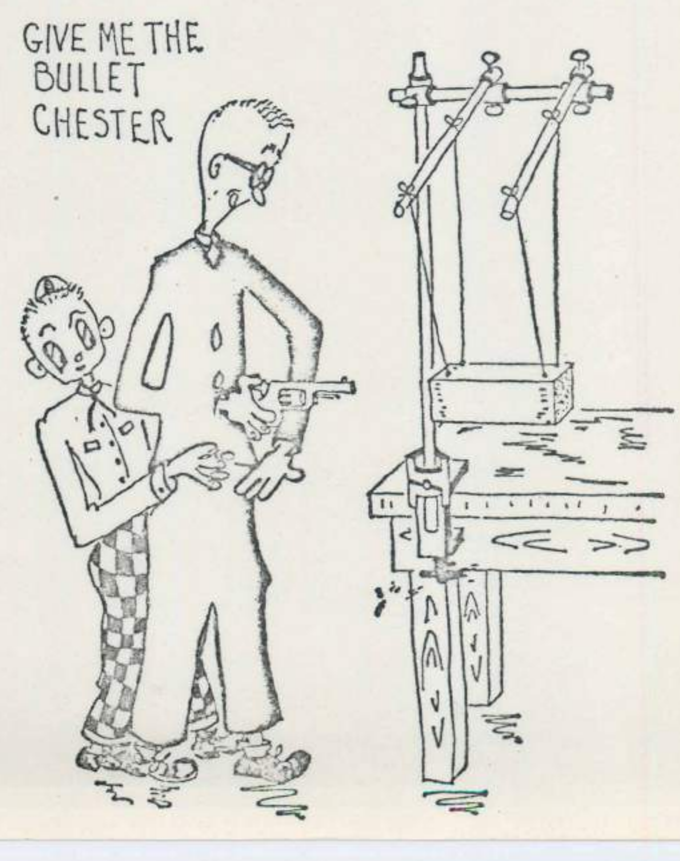
Obtain a dynamic rubber band (one you used to accelerate the carts). After making appropriate measurements, mount the rubber band on supports in such a manner to make a sling-shot. Using a lead mass, predict the range of the lead mass when you pull the rubber band a given amount. After you have made all the calculations, ask your instructor to oversee the actual firing.

19. Complete the 3 question written exercise and have it evaluated.



"Laws of physics, my eye! I'm a practical man"

"GEORGE" By G. Freier



Chapter 8 Answers

1. (a) F is proportional to x

2. (a) Work done to stretch or compress the spring (equals the change in U_s)
(b) Area = $W = U_s = \frac{1}{2}Fx$ (c) kx (d) $\frac{1}{2}kx^2$
(c) spring potential energy U_s

3. (a)(1) moving mass (2) kinetic energy (3) $E_K = \frac{1}{2}mv_o^2$
(b)(1) $\frac{1}{2}mv^2$ (2) less (3) stored in spring (4) $\frac{1}{2}kx^2$, $\frac{1}{2}mv_o^2 - \frac{1}{2}mv^2$
(5) kinetic, potential (6) $\frac{1}{2}mv^2 + \frac{1}{2}kx^2$
(c)(1) stored in spring (2) $\frac{1}{2}kx^2_{max}$ (3) $x = \sqrt{m/k}\ v_o$

4. (1) (a) when compression is greatest (b) at same point (c) zero
(2) find the slope of the graph
(3) (a) yes as force depends only on distance (b) 18 joules (c) 0.15 m (d) $\frac{1}{2}$
(19) (a) 0.5 joules (b) 0.5 joules (c) 0.3 joules
(22) (a) 100 N/m (b) S.A.B.

8. (23) (a) 18 joules (b) S.A.B. (c) S.A.B.
(24) S.A.B.
(25) S.A.B.
(26) (a) 1.00 kg m/s (b) 0.500 kg m/s, 2.00 kg m/s, 4.00 kg m/s (c) 1.00 joule

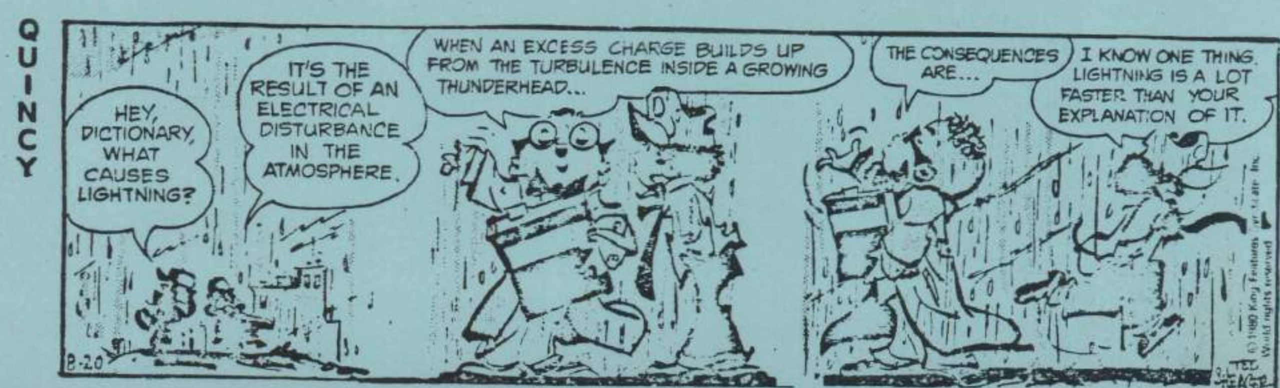
10. (b) F = ma because mass of the earth is much greater than the mass of the object
(c) m g h

11. (a)

	U_g	E_k	v
(at a)	= 235 joules	= 0	= 0 m/sec
(at b)	= 176.4 joules	= 58.6 joules	= 6.25 m/sec
(at c)	= 117.5 joules	= 117.5 joules	= 8.85 m/sec
(at d)	= 0	= 235 joules	= 12.5 m/sec

13. (8) 3.4×10^3 joules
(9) 79.2 joules (b) 79.2 joules (c) 22.3 m/s
(10) (a) 18 m/s (b) 80% (c) 2.0×10^3 N
(27) S.A.B.
(29) (a) S.A.B. (b) 0.78 m
(30) (a) 1.5 joules (b) 0.4 joules (c) 1.1 joules (d) 1.1 joules (e) 0.4 joules
(31) S.A.B.

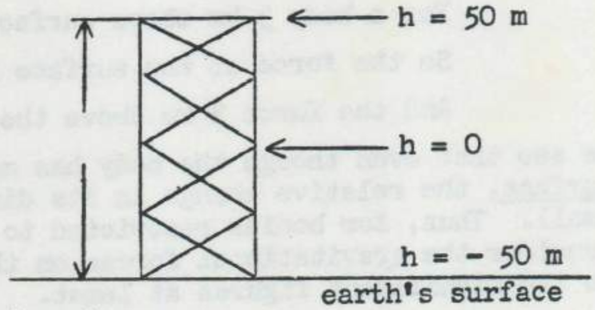
16. (13) (a) 0.20 m (b) oscillating, as high as on left, 1.2 joules (c) −0.5 joules
(14) increase
(15) an additional E_K
(17) $G\,m\,M\,/\,(10\ r_e)$
(33) 2.3×10^{-18} joules
(34) (a) 4.4×10^9 joules (b) 3.9×10^{28} joules
(35) 5.6×10^6 joules
(36) (a) 6.24×10^9 joules (b) 4.43×10^{10} joules (c) 8



Chapter 8 STUDY NOTES

1. Reference Points of Potential Energy

It is important to understand that we can assign unique values of potential energy to objects only after we have first defined a reference point where the potential energy is zero. The value of the potential energy depends on this choice of reference point, so when doing a calculation you must measure all potential energies relative to the same reference point.



For motion of a body near the surface of the earth, it is not sufficient to say only that $U = mgh$. You must also specify the place chosen as the reference point: at this reference point both U and h are <u>defined</u> to be zero. If we have a tower 100 m high and define the reference point to be half-way up the tower: then a 1-kg mass has a potential energy of zero when half-way up. At the ground the potential energy of the 1-kg mass is given by:

$$U = mgh_{ground} = (1\text{ kg})\,(9.8\text{ m/s}^2)\,(-50\text{ m}) = -490\text{ Joules}$$

And at the top, the potential energy of the 1-kg mass is:

$$U = mgh_{top} = (1\text{ kg})\,(9.8\text{ m/s}^2)\,(50\text{ m}) = +490\text{ Joules}$$

If we choose a different reference point, the value of the object's potential energy at each height will be different. For instance, if we choose the reference point to be the top of the tower, then at the ground, $h_{ground} = -100$ m, and

$$U_{ground} = (1\text{ kg})\,(9.8\text{m/s}^2)\,(-100\text{ m}) = -980\text{ Joules}$$

for our 1-kg object. This result clearly does not agree with the value of the potential energy at the ground when the reference point was chosen to be 'half-way' up.

Note, however, that independent of our choice of reference point, the <u>change</u> in potential energy when the 1-kg object moves from the bottom of the tower to the top is +980 Joules. This is a general result: the value of the potential energy will always depend on an arbitrary choice of reference point, but the change in potential energy when the object moves from one place to another will <u>never</u> depend on the choice of reference point.

While our examples in this study note involved motion near the surface of the earth, the results expressed are generally valid. For bodies at large distances from one another, the potential energy due to gravity is given by the equation: $U = -GmM/R$ where R is the separation of the two bodies. In this case, the reference point is $R = \infty$, so that when R is infinite ($R = \infty$) the potential energy is zero: $U = 0$ when $R = \infty$. Be sure to keep these reference points in mind whenever you deal with potential energy.

2. Gravitational Fields

You may find it strange that we analyze the motion of particles under the influence of gravity using different force laws in different circumstances. There is really only one correct law of universal gravitation, and it states that the force of attraction between two masses varies as the inverse square of the distance between them. Yet <u>for bodies which remain close to the surface of the earth</u>, we can say that the gravitational force between the body and the earth is a constant; that the force does not depend at all on the distance between the body and the earth. This is an approximation which is quite valid as long as the body remains near the earth's surface. To see why it is valid, remember that what determines the magnitude of the gravitational force between an object and the earth is the distance from the object to the <u>center</u> of the earth - not the distance from the object to the earth's surface.

(con't)

Let's compare the gravitational force on a 1.000 kg body at the surface of the earth and the gravitational force on a 1.000 kg body 3.000 km above the surface of the earth. We'll perform the calculation to four significant figure accuracy.

The universal force law is: $F = G\,M_e\,M_{obj}/R^2$

For a body on the surface: $R = 6.378 \times 10^6$ m

For a body 3 km above surface: $R = 6.378 \times 10^6 \text{ m} + 3 \times 10^3 \text{ m} = 6.381 \times 10^6$ m

So the force at the surface is: 9.817 Newtons

And the force 3 km above the surface is: 9.801 Newtons

We see that even though the body has moved a reasonably large distance from the earth's <u>surface</u>, the relative change in its distance from the center of the earth is quite small. Thus, for bodies restricted to within 3 km of the earth's surface, we can consider the gravitational forces on these bodies to be independent of their position - to two significant figures at least.

So for bodies confined to locations near the surface of the earth, the force is given by the <u>approximate</u> relation:

$$F = mg \quad [\text{where } g \text{ is a constant equal in magnitude to } 9.8 \text{ m/s}^2]$$

The associated expression for the potential energy is:

$$U = mgh \quad [U \text{ is defined to be zero where } h = 0; \;\; g = +9.8 \text{ m/s}^2]$$

Remember that this formula is an approximation, with limited validity.

For bodies free to move far from the earth's surface, the general law of gravity (which is always valid) must be used. The force law is:

$$F = G\,m\,M_e/R^2$$

and the corresponding potential energy is:

$$U = -G\,m\,M_e/R \quad [\text{where } U \text{ is defined to be zero infinitely far from earth}]$$

Note that this force law and potential energy formula apply to <u>any</u> two bodies interacting via gravity; the earth need not be involved. Also note that you can apply this universal gravitation formula to motion near the surface of the earth; however, it is much more cumbersome and will give you nearly the same results as the approximation: $F = mg$.

3. <u>The "Sign" of the Potential Energy</u>

Once we define a certain point to be at "zero" potential energy, it is conceivable that an object can move to a position where its potential energy is negative. This is perfectly okay; potential energies can be both positive and negative, but it does raise some algebraic problems.

For instance, which is the greater potential energy:

$U = -1$ Joule? or $U = -2$ Joules?

The answer is that $U = -1$ Joule is greater. When you deal with negative numbers, a number which is "less negative" has a greater value. If a body moves from a location where its potential energy is -1 Joule, its potential energy increases.

The "Sign" of the Total Mechanical Energy

Recall from the previous study notes that potential energies can be negative quantities. This results from the arbitrary definition of a reference point where the potential energy is zero. Now if potential energy can be negative, and if total mechanical energy is defined as the sum of potential and kinetic energies, then the total mechanical energy can in certain cases be negative also.

Let's see how this can happen. For a particle under the influence of an "inverse square" gravitational force field, we may write the total mechanical energy as:

$$E_T = E_K + U = \tfrac{1}{2}mv^2 - GmM/R$$

where we have chosen the zero of potential energy to be at $R = \infty$. If a satellite of mass 1000 kg has a speed of 2000 m/s at a distance of 10^7 meters from the center of the earth, we see that the total mechanical energy is negative.

$$E_T = \tfrac{1}{2}(1000\text{ kg})(2000\text{ m/s})^2 - \frac{6.7 \times 10^{-11}\text{ Nt m}^2/\text{sec}^2)(6.0 \times 10^{24}\text{ kg})(10^3\text{ kg})}{10^7\text{ m}}$$

$$E_T = (2 \times 10^9\text{ Joules}) - (4 \times 10^{10}\text{ Joule}) = -3.8 \times 10^{10}\text{ Joules}$$

So if you calculate a negative value for total mechanical energy, it's not necessarily wrong; a negative value of total mechanical energy is "conserved" in the same manner as a positive value. In general, don't be thrown by the fact that the total mechanical energy is sometimes negative.

The "Sign" of the Binding Energy

When studying binding energy and escape velocity, note that a particle in an "inverse square" gravitational force field is not bound if its total energy is positive but is bound if its total energy is negative.

This results from our arbitrary choice of a reference point for potential energy, and one of the reasons we choose $R = \infty$ as the reference point is that it provides this convenient distinction between bound and unbound particles:

$E_T < 0 \Rightarrow$ bound, $E_T \geq 0 \Rightarrow$ unbound, [for inverse square gravitation only!]

If we had chosen a different reference point for potential energy, we would still be able to distinguish between bound and unbound particles by examining the total energy, but the criterion would be different.

The binding energy is defined as the minimum amount of energy we would have to add to a bound particle to enable it to escape. The binding energy is therefore always a positive number. Note the distinction:

1. total mechanical energy of a bound particle is negative
2. binding energy of a bound particle is positive

As you saw from the discussion in the text, the positive value of the binding energy is given by:

binding energy $= -E_T$

where E_T is the negative value of the total mechanical energy of the bound particle.

WHAT GOES UP MUST COME DOWN

The following was garnered from the pages of the Lake Erie Amateur Radio Association repeater newsletter.

According to a footnote, identity of the original author is "lost in antiquity".

The ham is sitting at his desk, answering a letter from his insurance company:

I am writing in response to your request for additional information for Block No. 3 of the accident reporting form. I put 'poor planning' as the cause of my accident. You said in your letter that I should explain more fully, and I trust that the following details will be sufficient.

I am an amateur radio operator and, on the day of the accident, I was working alone on the top section of my new 80-foot tower. When I had completed my work, I discovered that I had, over the course of several trips up the tower, brought up about 300 pounds of tools and spare hardware.

Rather than carry the now unneeded tools and materials down by hand, I decided to lower the items in a small barrel by using a pulley, which fortunately was attached to the gin pole at the top of the tower.

Securing the rope at ground level, I went to the top of the tower and loaded the tools and material into the barrel. Then I went back to the ground and untied the rope, holding it tightly to ensure a slow descent of the 300 pounds of tools.

(You will note in Block No. 1 of the accident reporting form that I weigh just 155 pounds.)

Due to my surprise at being jerked off the ground so suddenly, I lost my presence of mind and forgot to let go of the rope. Needless to say, I proceeded at a rather rapid rate of speed up the side of the tower.

In the vicinity of the 40-foot level, I met the barrel coming down. This explains my fractured skull and broken collarbone.

Slowed only slightly, I continued my rapid ascent, not stopping until the fingers of my right hand were two knuckles deep into the pulley.

Luckily, by that time I had regained my presence of mind and was able to hold onto the rope, in spite of my pain. At approximately the same time, however, the barrel of tools hit the ground and the bottom fell out of the barrel.

Devoid of the weight of the tools, the barrel now weighed only about 20 pounds. I refer you again to my weight in Block No. 1. As you might imagine, I began a rather rapid descent down the side of the tower.

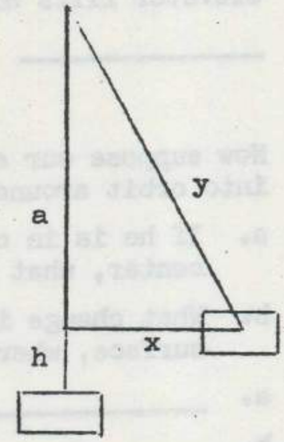
In the vicinity of the 40-foot level, I met the barrel coming up. This accounts for the two fractured ankles and the lacerations on my legs and lower body.

However, the encounter with the barrel slowed me enough to lessen my injuries: when I fell onto the pile of tools I was fortunate to have only three vertebrae cracked.

I am sorry to report, however, that as I lay there on the tools in pain, unable to stand and watching the empty barrel 80 feet above me, I again lost my presence of mind; I let go of the rope.

And you think you've got troubles!

Chapter 8 BB GUN EXPERIMENT



MASS DATA

mass one BB (m) ____________ g ________________ kg

mass clay (M) ____________ g ________________ kg

mass (m+M) ____________ g ________________ kg

VELOCITY DATA AND CALCULATIONS

velocity of bullet (v)
velocity of bullet and clay (V)

length of pendulum (y) ________________ m

distance (x) ________________ m

distance (a) ________________ m $\qquad a = \sqrt{y^2 - x^2}$

distance y - a = h ________________ m

velocity (V) ________________ m/sec

velocity (v) ________________ m/sec

$$1/2\ (m+M)V^2 = (m+M)gh \quad : \quad V = 2gh$$

$$mv = (m+M)V \quad : \quad v = \frac{(m+M)V}{m}$$

ENERGY DATA

E_K (before) = $1/2\ mv^2$ ________________ j $\qquad$ Loss E_K ____________ j

E_K (after) = $1/2\ (m+M)V^2$ ________________ j $\qquad$ % Loss ____________ %

ADDITIONAL CALCULATIONS

$$mv = (m+M)V \quad : \quad V = mv/(m+M)$$

$$E_K \text{ (after)} = 1/2\ (m+M)V^2 = 1/2\ (m+M)\ \frac{(mv)^2}{(m+M)^2} = \frac{1}{2}\ \frac{(mv)^2}{(m+M)} = \left(\frac{m}{m+M}\right)\left(\frac{1}{2}\ mv^2\right)$$

a. $x^2 = v_1^2 + v_2^2$ $\qquad v_2^2 = x^2 - v_1^2$ $\qquad x = 1\times10^7$ m/s

b. $x = .866\, v_1 + v_2 \cos\theta$

$(x - .866\, v_1)^2 = v_2 \cos\theta$

$x^2 - 1.73x\, v_1 + .75\, v_1^2 = v_2^2 \cos^2\theta$

c. $0 = .5\, v_1 + v_2 \sin\theta$

$-.5\, v_1 = v_2 \sin\theta$

$.25\, v_1^2 = v_2^2 \sin^2\theta$

a+b $\quad x^2 - 1.73\, x\, v_1 + .75\, v_1^2 = v_2^2 \cos^2\theta$

$.25\, v_1^2 = v_2^2 \sin^2\theta$

d $\quad x^2 - 1.73\, x\, v_1 + v_1^2 = v_2^2$

a = d $\quad \cancel{x^2} - v_1^2 = \cancel{x^2} - 1.73\, x\, v_1 + v_1^2$

$2 v_1^2 = 1.73\, x\, v_1$

$2 v_1^2 - 1.73\, x\, v_1 = 0$

$v_1 (2 v_1 - 1.73\, x) = 0$ $\qquad v_1 = 0$

or $\quad 2 v_1 = 1.73\, x$ $\qquad v_1 = .866\, x$ $\qquad = 8.66\times10^6$ m/s

a $\quad v_2^2 = x^2 - v_1^2$

$v_2^2 = x^2 - (.866\, x)^2$

$= x^2 - .75\, x^2$

$v_2^2 = .25\, x^2 = .5\, x = 5\times10^6$ m/s

c. $-.5\, v_1 = v_2 \sin\theta$

$-\frac{.5\, v_1}{v_2} = \sin\theta$

$-\frac{.5\,(.866\, x)}{.5\, x} = \sin\theta$

$-.866 = \sin\theta$

$\theta = -60^\circ$

$v_2 = 0.5 \times 10^7 \, m/s$

1 $\frac{1}{2} m (1 \times 10^7 \, m/s)^2 = \frac{1}{2} m v_1^2 + \frac{1}{2} m v_2^2$

2 $m (1 \times 10^7 \, m/s) = m v_1 \cos 30^\circ + m v_2 \cos\theta$

3 $0 = m v_1 \sin 30^\circ + m v_2 \sin\theta$

1. $x^2 = v_1^2 + v_2^2$ $\qquad v_1^2 = x^2 - v_2^2$

2 $x = .866\, v_1 + v_2 \cos\theta$

3 $0 = .5\, v_1 + v_2 \sin\theta$

2. $x^2 = .75\, v_1^2 + .866\, v_1 v_2 \cos\theta + v_2^2 (\cos\theta)^2$

1 into 2 $x^2 = .75x^2 - .75 v_2^2 + (2).866 \sqrt{x^2 - v_2^2}\; v_2 \cos\theta + v_2^2 (\cos\theta)^2$

3. $0 = .5 v_1 + v_2 \sin\theta$

1 with 3 $0 = .5\sqrt{x^2 - v_2^2} + v_2 \sin\theta$ $\qquad v_2 = \frac{.5x}{\sqrt{.25 + (\sin\theta)^2}}$

$-.5\sqrt{x^2 - v_2^2} = v_2 \sin\theta$

$.25x^2 - .25 v_2^2 = v_2^2 (\sin\theta)^2$

$.25x^2 = .25 v_2^2 + v_2^2 (\sin\theta)^2$

$\frac{.25x^2}{.25 + (\sin\theta)^2} = v_2^2$

INTO (2) $.25x^2 = -.75\left[\frac{.25x^2}{.25 + (\sin\theta)^2}\right] + 1.732\sqrt{x^2 - \left[\frac{.25x^2}{.25 + (\sin\theta)^2}\right]}\; \frac{.5x}{\sqrt{.25 + (\sin\theta)^2}} \cos\theta + \frac{.25x^2}{.25 + (\sin\theta)^2} (\cos\theta)^2$

$.25x^2 = \frac{-.1875\, x^2}{.25 + (\sin\theta)^2} + 1.732 \cdot .5x \sqrt{\frac{.25x^2 + (\sin\theta)^2 x^2 - .25x^2}{.25 + (\sin\theta)^2}}\; \frac{\cos\theta}{\sqrt{.25 + (\sin\theta)^2}} + \frac{.25x^2}{.25 + (\sin\theta)^2} (\cos\theta)^2$

$.25x^2 = \frac{-.1875x^2}{.25 + (\sin\theta)^2} + .866\, x \cos\theta \sqrt{\frac{(\sin\theta)^2 x^2}{[.25 + (\sin\theta)^2][.25 + (\sin\theta)^2]}} + \frac{.25x^2 (\cos\theta)^2}{.25 + (\sin\theta)^2}$

$.25x^2 = -\frac{.1875x^2}{.25 + (\sin\theta)^2} + \frac{.866\, x^2 \cos\theta \sin\theta}{.25 + (\sin\theta)^2} + \frac{.25x^2 (\cos\theta)^2}{.25 + (\sin\theta)^2}$

$.0625x^2 + .25x^2 (\sin\theta)^2 = -.1875x^2 + .866x^2 \cos\theta \sin\theta + .25x^2 (\cos\theta)^2$

$.0625x^2 + .1875x^2 = .25x^2 (\cos\theta)^2 + .866\, x^2 \cos\theta \sin\theta - .25x^2 (\sin\theta)^2$

$.25x^2 = .25x^2 (\cos\theta)^2 + .866\, x^2 \cos\theta \sin\theta - .25x^2 (\sin\theta)^2$

$1 = (\cos\theta)^2 + 3.46 \cos\theta \sin\theta - (\sin\theta)^2$

$1 = \cos^2\theta + 3.46 \cos\theta \sin\theta - \sin^2\theta$

$1 = 1 - \sin^2\theta + 3.46 \cos\theta \sin\theta - \sin^2\theta$

$0 = -2\sin^2\theta + 3.464 \cos\theta \sin\theta$

$0 = -2\sin\theta + 3.464 \cos\theta$

$2\sin\theta = 3.46 \cos\theta$

$\frac{\sin\theta}{\cos\theta} = \frac{3.46}{2} = \tan\theta$ $\qquad \theta = 60^\circ$

$v_2^2 = \frac{.25x^2}{.25 + (\sin\theta)^2} = \frac{.25 \times 1 \times 10^{14} \frac{m^2}{s^2}}{.25 + (\sin 60^\circ)^2} = 2.5 \times 10^{13} = v_2^2$ $\qquad v_2 = 5.0 \times 10^6 \, m/s$

$v_1^2 = x^2 - v_2^2$ $\qquad 1 \times 10^{14} \, m^2/s^2 - 2.5 \times 10^{13} \frac{m^2}{s^2} = v_1^2$ $\qquad v_1 = 8.66 \times 10^6 \, m/s$

A. CONSERVATION OF ENERGY

(1) $\frac{1}{2} \times 5\,\text{Kg} \times 4(\frac{M}{SEC})^2 = \frac{1}{2} \times 5\,\text{Kg} \times v_1^2 + \frac{1}{2} \times 5\,\text{Kg} \times v_2^2$

B. CONSERVATION OF MOMENTUM

(2) HORIZONTAL $\rightarrow$ $5\,\text{Kg} \times 4\,\text{M/SEC} = 5\,\text{Kg} \times v_1 \cos 45^\circ + 5\,\text{Kg} \times v_2 \cos\theta$

(3) VERTICAL $\rightarrow$ $0 = 5\,\text{Kg} \times v_1 \sin 45^\circ + 5\,\text{Kg} \times v_2 \sin\theta$

C. SIMPLIFICATION (LET $x = 4\,\text{M/sec}$)

(1)′ $x^2 = v_1^2 + v_2^2$: $v_1^2 = x^2 - v_2^2$: $v_1 =$

(2)′ $x = 0.707\, v_1 + v_2 \cos\theta$

(3)′ $0 = 0.707\, v_1 + v_2 \sin\theta$

D. SQUARE EQUATION (2)′

(4) $x^2 = 0.5 v_1^2 + 1.414\, v_1 v_2 \cos\theta + v_2^2 \cos^2\theta$

E. SUBSTITUTE (1)′ INTO (4), THEN SIMPLIFY

(5) $x^2 = 0.5(x^2 - v_2^2) + 1.414\, v_2 \cos\theta \sqrt{x^2 - v_2^2} + v_2^2 \cos^2\theta$

(6) $x^2 = 0.5x^2 - 0.5 v_2^2 + 1.414\, v_2 \cos\theta \sqrt{x^2 - v_2^2} + v_2^2 \cos^2\theta$

F. SUBSTITUTE (1)′ INTO (3)′, THEN SIMPLIFY

(7) $0 = 0.707 \sqrt{x^2 - v_2^2} + v_2 \sin\theta$

(8) $-0.707 \sqrt{x^2 - v_2^2} = v_2 \sin\theta$ NOW SQUARE BOTH SIDES

(9) $0.5(x^2 - v_2^2) = v_2^2 \sin^2\theta$

(10) $0.5x^2 - 0.5 v_2^2 = v_2^2 \sin^2\theta$

(11) $0.5x^2 = 0.5 v_2^2 + v_2^2 \sin^2\theta$

(12) $\frac{0.5x^2}{0.5 + \sin^2\theta} = v_2^2$: $v_2 = \sqrt{\frac{0.5x^2}{0.5 + \sin^2\theta}}$

G. SUBSTITUTE (12) INTO (6)

(13) $x^2 - 0.5x^2 = -0.5\left(\frac{0.5x^2}{0.5 + \sin^2\theta}\right) + 1.414 \cos\theta \sqrt{\frac{0.5x^2}{0.5+\sin^2\theta}} \sqrt{x^2 - \frac{0.5x^2}{0.5+\sin^2\theta}} + \frac{0.5x^2}{0.5+\sin^2\theta} \cos^2\theta$

12) $\frac{0.5x^2}{0.5 + \sin^2\theta} = v_2^2$

$\frac{0.5(4\,\text{M/s})^2}{0.5 + (.707)^2} = v_2^2$

(14) $0.5x^2 = -\frac{0.25x^2}{0.5 + \sin^2\theta} + 1.414 \cos\theta \sqrt{\frac{0.5x^2}{0.5+\sin^2\theta}} \sqrt{\frac{0.5x^2 + x^2\sin^2\theta - 0.5x^2}{0.5 + \sin^2\theta}} + \frac{0.5x^2}{0.5+\sin^2\theta} \cos^2\theta$

$\frac{8}{1} = v_2^2$

$2.83 \frac{M}{s} = v_2$

(15) $0.5x^2 = -\frac{0.25x^2}{0.5 + \sin^2\theta} + 1.414 \cos\theta \sqrt{\frac{0.5x^2}{0.5+\sin^2\theta}}\, x \sin\theta \sqrt{\frac{1}{0.5+\sin^2\theta}} + \frac{0.5x^2}{0.5+\sin^2\theta} \cos^2\theta$

(16) $0.5x^2 = -\frac{0.25x^2}{0.5 + \sin^2\theta} + \frac{1.414 \cos\theta \sin\theta\, x^2 \sqrt{0.5}}{0.5 + \sin^2\theta} + \frac{0.5x^2 \cos^2\theta}{0.5 + \sin^2\theta}$

′ $x^2 = v_1^2 + v_2^2$

$x^2 - v_2^2 = v_1^2$

(17) $0.5x^2(0.5 + \sin^2\theta) = -0.25x^2 + \cos\theta \sin\theta\, x^2 + 0.5x^2 \cos^2\theta$

$(4\frac{M}{S})^2 - 8\frac{M^2}{S^2} = v_1^2$

(18) $0.25 + 0.5 \sin^2\theta = -0.25 + \cos\theta \sin\theta + 0.5 \cos^2\theta$

$8\frac{M^2}{S^2} = v_1^2$

(19) $0.50 = -0.5 \sin^2\theta + \cos\theta \sin\theta + 0.5 \cos^2\theta$

$2.83 \frac{M}{S} = v_1$

(20) $1 = -\sin^2\theta + 2\cos\theta \sin\theta + \cos^2\theta$

(21) $1 = -\sin^2\theta + 2\cos\theta \sin\theta + 1 - \sin^2\theta$

(22) $0 = -2\sin^2\theta + 2\cos\theta \sin\theta$

(23) $0 = -\sin\theta + \cos\theta$

(24) $\sin\theta = \cos\theta$

(25) $\frac{\sin\theta}{\cos\theta} = 1 = \tan\theta$ $\theta = 45^\circ$

A. NEAR EARTHS SURFACE

1. $E_T = E_K + U = \frac{1}{2} mv^2 + mgh$

B. IN GENERAL

1. KNOW GRAVITY VARIES FROM PLACE TO PLACE

$F = ma = G\frac{mM}{R^2} \Rightarrow g = G^M/_{R^2} \; : \; mgh = m\frac{GM}{R^2}h = \frac{GmM}{R}$

2. PROPER DETERMINATION OF U_g

$$\Delta U_g = \int_a^b F dR = \int_a^b G\frac{mM}{R^2} dR = GmM\int_a^b R^{-2} dR = \underbrace{-\frac{GmM}{R}\Big]_a^b}_{=U_g}$$

$$= -\frac{GmM}{b} - \left(-\frac{GmM}{a}\right)$$

3. ΔU_g FROM $R \rightarrow \infty$

$$\Delta U_g = \int_R^\infty F dR = \int_R^\infty G\frac{mM}{R^2} dR = GmM\int_R^\infty R^{-2} dR = -\frac{GmM}{R}\Big]_R^\infty$$

$$\Delta U_g = -\frac{GmM}{\infty} - \left(-\frac{GmM}{R}\right)$$

BY DEFINITION $U_g(\text{at } \infty) = 0$

$\therefore \Delta U_g = G^{mM}/_R$

4. WHY IS U_g NEGATIVE?

5. WHAT IS TOTAL MECHANICAL ENERGY?

a. $E_T = E_K + U = \frac{1}{2} mv^2 + \left(-G^{mM}/_R\right) = \frac{1}{2} mv^2 - G\frac{mM}{R}$

b. UNDER INFLUENCE OF GRAVITY

THROW UP OBJECT, GAIN IN U_g due to loss IN E_K

6. SUMMARY

$U_R = -\frac{GmM}{R}$, $U_\infty = 0$

WANT E_K TO ESCAPE

C. LET'S LAUNCH OBJECT → WANT IT TO GET FAR AWAY (IGNORE OTHER PLANETS)

1. NEED $\Delta U = G^{mM}/_R$ (AT ∞ $U = 0$, E_K from max → 0)

2. $E_K = \frac{GmM}{R}$

3. $\frac{E_K}{m} = \frac{GM_e}{R_e} = \frac{6.67 \times 10^{-11} \, NT \cdot M^2}{Kg^2} \times \frac{5.98 \times 10^{24} Kg}{6.38 \times 10^6 M} = 6.25 \times 10^7 \; \frac{Joules}{Kg}$

$= 12\, v_e = 4\, 1R_e = 6.25 \times 10 \quad 1Kg$

$v_e = 1.12 \times 10^4\ M/s = 11.2\ KM/s = 6.96\ Mi/sec = 2.51 \times 10^4\ \frac{Mi}{HR} = 25{,}054\ \frac{Mi}{HR}$

(for ANY OBJECT)

E. HOW MUCH E_K NEEDED TO PUT INTO ORBIT VS E_K TO ESCAPE?

ASSUMPTIONS: 1. CIRCULAR ORBIT

2. $R_{ORBIT} = R_e$

1. $F = \frac{mv^2}{R} = G\frac{mM}{R^2} \Rightarrow mv^2 = \frac{GMm}{R_e}$

2. $E_K = \frac{1}{2} mv^2 \therefore E_K\ (\text{INTO ORBIT}) = \frac{1}{2} G\, Mm/R$

$\therefore$ $\frac{1}{2}$ E_K NEEDED

F. WHAT IS THE TOTAL ENERGY OF ORBITING SATELLITE

1. $E_T = E_K + U = \frac{1}{2}\frac{GmM_e}{R_e} + \left(-\frac{GmM_e}{R_e}\right) = -\frac{1}{2}\frac{GmM}{R_e}$

$(-) \Rightarrow$ DO WORK TO GET IT TO $E_T = 0$ AT ∞

2. IF $E_T < E_{\text{To ESCAPE}} \Rightarrow$ BOUND TO EARTH

3. BINDING ENERGY $\rightarrow$ ENERGY NEEDED TO ESCAPE

ON EARTH : $+\frac{GmM_e}{R_e}$ $\qquad m = 70\,Kg \quad E_{BIND} = 4.4 \times 10^9$ Joules

ORBITING SATELLITE $= +\frac{1}{2} G\frac{mM}{R_e}$ (AT R_e)

G. BINDING ENERGY - EARTH TO SUN

$E_{BINDING} = \frac{1}{2} G \cdot \frac{m_e M_S}{R_{\text{earth orbit}}} \sim 2 \times 10^{33}$ Joules

H. IN GENERAL (object in a gravitational field)

$E = \frac{1}{2} mv^2 - \frac{GMm}{R}$

IF NEGATIVE (BOUND)

$-E = \frac{GMm}{R} - \frac{1}{2} mv^2$

Honors Physics   Chapter 8 Test   Name Key

(30)

30 + 8 + 33 = 71

30 + 8 + 16 + 17 = 71

1. C
2. E
3. D
4. ~~B~~ C
5. B
6. A
7. E
8A. C
8B. A
8C. B
9A. C
9B. A
9C. C
10. C
11. B

Column I below lists a number of physical quantities. Column II lists a number of SI units.

In the space provided before each quantity in Column I, write the letter corresponding to the appropriate SI unit from Column II. A particular unit from Column II may be used once, more than once, or not at all.

(8) 14

		I		II
		Physical Quantity		SI Unit
B	1.	acceleration	(A)	m/s
I	2.	coefficient of friction	(B)	m/s^2
G	3.	energy	(C)	m^2/s^2
E	4.	force	(D)	kg·m/s
G	5.	heat	(E)	$kg \cdot m/s^2$
H	6.	power	(F)	$kg \cdot m^2/s$
A	7.	speed	(G)	$kg \cdot m^2/s^2$
G	8.	work	(H)	$kg \cdot m^2/s^3$
			(I)	no unit

P-1

24

5

Consider the following data for the restoring force $\vec{F}$ exerted by a spring extended through a displacement $\vec{x}$.

For what range of forces does the spring obey Hooke's Law?

0 → 150 N

$\vec{x}$ (m)	$\vec{F}$ (N)
0.10	60
0.15	90
0.20	120
0.25	150
0.30	190
0.35	245

P-2

2

(5)

A squirrel gathers 600 nuts together on the ground before storing them in a tree. What is the minimum amount of work done by the squirrel in storing the nuts if the mass of each nut is 0.010 kg and the store house is 6.0 m above the ground? (g = 10 N/kg)

3.6×10^2 J

$N = 600$

$m_1 = 0.01$ kg

$\Delta h = 6.0$ m

$W = F\Delta x = mg\Delta h$

$600 \times \frac{1}{100}$ kg $\times 10 \frac{N}{kg} \times 6$ m

W = 360 Joules

3 if forgot 600 nuts

P-3

16

(6)

Assume that a space capsule having a mass of 900 kg is projected vertically upward from the earth's surface. The mass of the earth is 5.98×10^{24} kg, the radius of the earth is 6.38×10^6 m, and the gravitational constant is 6.67×10^{-11} $N \cdot m^2/kg^2$.

2

Neglecting air resistance, determine the initial speed that the capsule will need in order to "just escape".

11.2 km/sec

$m = 900$ kg

$M = 5.98 \times 10^{24}$ kg

$R = 6.38 \times 10^6$ M

$G = 6.67 \times 10^{-11} \frac{N \cdot M^2}{kg^2}$

$v_e = \sqrt{\frac{2GM}{r}}$

$\Delta KE = \Delta U_g$

$E_{k_i} = U_{g_i}$

$\frac{1}{2}\cancel{m}v^2 = \frac{G\cancel{m}M}{R}$

$v^2 = \frac{2GM}{R}$

$v = 2 \times 6.67 \times 10^{-11} \frac{N M^2}{kg^2} \times \frac{5.98 \times 10^{24} kg}{6.38 \times 10^6 M} \frac{M}{s^2}$

$v = 1.12 \times 10^4 \frac{M}{sec}$ = 11.2 $\frac{Km}{sec}$

68

HONORS PHYSICS CH-8

4

A spring suspended at rest is shown in diagram I.

Diagram II shows a 1.0 kg mass hanging at rest from the same spring and causing an extension of 20 cm.

To extend the spring from position I to position III, as shown in the diagram, requires 2.25 J of work.

The spring constant is 50 N/m and g = 10 N/kg.

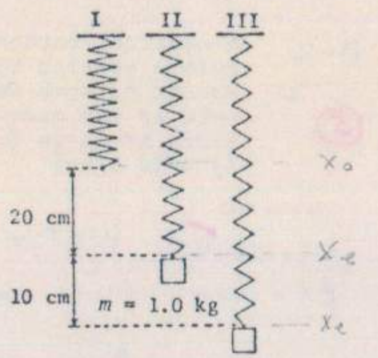


Diagram not drawn to scale

#11 (a) If the mass is released from the position shown in diagram III, what will be the extension of the spring when the mass reaches its maximum speed? 0.20 M

(b) Calculate the maximum speed of the mass. .71 M/sec

5

(a) Max speed at X_e

$K = 50 \frac{N}{M}$

$g = 9.8 \frac{M}{s^2}$

$m = 1 Kg$

(b) $\frac{1}{2} m v^2 = \frac{1}{2} k x^2$

$v^2 = \left(\frac{K}{m}\right) x^2$

$v = \sqrt{\frac{K}{m}}\, x =$

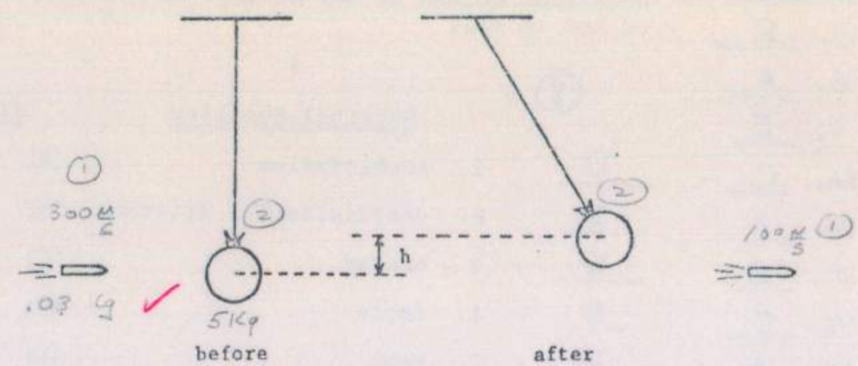
$\sqrt{\frac{50 \, Kg}{1.0 \, Kg \, M \, s^2}} \times \frac{1}{10} M$

$v = .31 \frac{M}{S \cdot M} \cdot \frac{1}{10} M$

$v = .71 \frac{M}{S}$

P-5 4

A 5.0 kg sandbag is suspended by a light cord as shown in the diagram. A 30 g bullet, travelling with a horizontal velocity of 300 m/s, penetrates the sandbag and leaves with a horizontal velocity of 100 m/s. The collision is inelastic.



5 What is the speed of the sandbag immediately after the interaction with the bullet? 1.2 m/sec

$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$

$\frac{m_1 v_1 - m_1 v_1' + m_2 v_2}{m_2} = v_2'$

$\frac{\frac{3}{100} Kg \cdot 300 \frac{M}{S} - \frac{3}{100} Kg \cdot 100 \frac{M}{S}}{5 Kg}$

$\frac{9 - 3}{5} = \frac{6}{5} = 1.2 \frac{M}{S}$

#25 P-6

5 Calculate the energy stored in an ideal spring having a spring constant of 400 N/m when it is compressed 0.30 m. 18 Joule

$K = 400 \frac{N}{M}$

$X = \frac{3}{10} M$

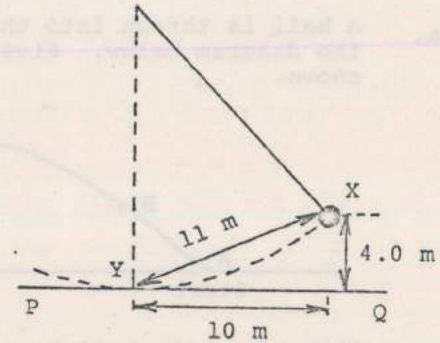
$U_s = \frac{1}{2} K x^2$

$= \frac{1}{2} \times 400 \frac{N}{M} \times \frac{9}{100} M^2$

$= 18 J$

1. [illegible] the accompanying diagram, point X indicates the position of the bob of a long pendulum of mass 2.0 kg which has been pulled aside. (g = 10 N/kg)

The gravitational potential energy of the bob with respect to point Y is closest to



(A) 8.0 J
80 J
(E) 2.2×10^2 J
(B) 40 J
(D) 2.0×10^2 J

2. A box of rivets falls from the top of a skyscraper under construction. As the box passes the 80th floor, it has a kinetic energy of E_k. By the time it passes the 20th floor its speed has doubled. By then its kinetic energy is

(A) $\frac{1}{4} E_k$
(C) E_k
$4\ E_k$
(B) $\frac{1}{2} E_k$
(D) $2\ E_k$

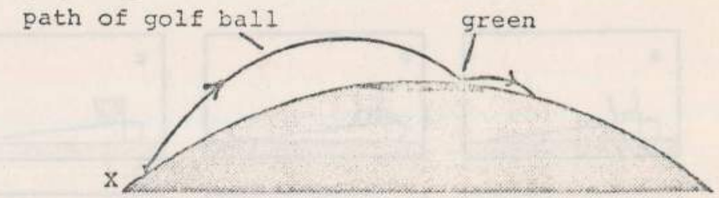
3. A girl exerts a 200 N force to lift a barbell to a vertical height of 2.0 m in 5.0 s. If she had done this in 10 s, the energy required would have been

(A) five times as great
the same
(B) four times as great
(E) half as great
(C) twice as great

4. A 20 kg mass is lifted to a height of 8.0 m above the earth and then moved sideways at a constant speed of 10 m/s. What is the kinetic energy of the mass if g = 10 N/kg?

(A) 1.0×10^2 J
(D) 1.6×10^3 J
(B) 8.0×10^2 J
(E) 2.6×10^3 J
1.0×10^3 J

5. A golf ball is hit from X toward the gre[illegible] at the top of a hill as shown below.



The potential energy of the golf ball is greatest when it

(A) leaves the golf club
reaches the highest point in its flight
(C) first hits the green
(D) bounces off the green
(E) comes to rest on the other side of the green

6. If friction is neglected, when an object falls from a position 300 m high, its total energy

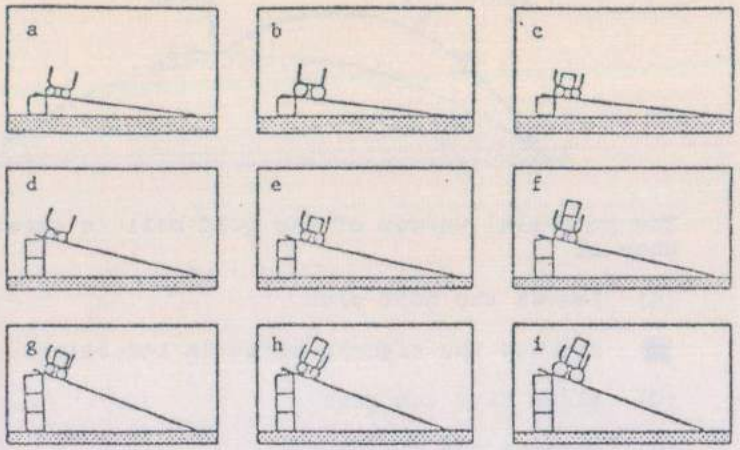
remains constant during the fall
(B) increases during the fall
(C) decreases during the fall
(D) is zero at the start of the fall
(E) is a maximum at the end of the fall

7. A baseball of mass m is moving with a speed v at a height h above the ground where the acceleration due to gravity is g.

Which of the following quantities are needed to determine the total mechanical energy of the baseball?

(A) h and m only
(D) g, m and v only
(B) g, h and m only
g, h, m and v
(C) m and v only

8.A. The following diagrams show different tests you can do with carts on ramps.



You want to test this idea: the higher a cart starts, the greater its speed at the bottom of the ramp. Which three tests would you use?

(A) a e i   c e g   (E) b d h

(B) c f i   (D) a d g

8.B. You want to test this idea: a cart with small wheels travels farther after leaving the ramp than a cart with large wheels. Which four tests would you use?

a b h i   (C) a b g i   (E) b d e f

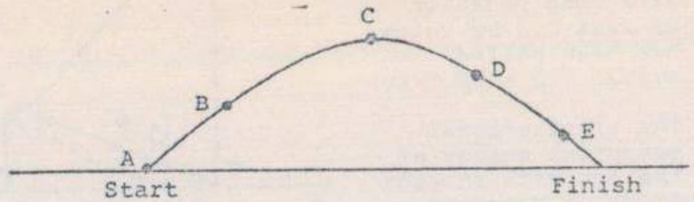
(B) b c f i   (D) b c e i

8.C. You want to test this idea: the heavier a cart and its load is, the greater its speed at the bottom of the ramp. Which three tests would you use?

(A) a e h   (C) c f i   (E) a b c

d e f   (D) g h i

9.A. A ball is thrown into the air and moves as shown in the diagram below. Five positions of the ball are shown.



Where does the ball have its maximum potential energy?

(A) A   C   (E) E

(B) B   (D) D

9.B. Where does the ball have the maximum kinetic energy?

A   (C) C   (E) E

(B) B   (D) D

9.C. Where is the gravitational potential energy of the ball equal to its kinetic energy?

(A) A   C   (E) E

(B) B   (D) D

10. A baseball is thrown upward with a speed of 20 m/s. (Assume $g = 10\ m/s^2$.)

The ball will rise to a maximum height of

(A) 80 m   20 m   (E) 1.0 m

(B) 30 m   (D) 10 m

11. A 6.0 kg mass is released from rest at a height of 80 m. If air resistance is negligible and $g = 10$ N/kg, the kinetic energy of the mass when it has fallen 60 m is

(A) 4.8×10^3 J   (C) 1.2×10^3 J   (E) zero

P.S.S.C. Physics Quiz # ___
Chapter 17 Kinetic Theory

Name ____________________
Date ____________

1. Seven particles of 5.0 grams mass bounce elastically back and forth along the X-axis of a three meter tube. Each particle has a constant speed of 30 meters/second.

A) What is the average force exerted on the area at the left end of the tube? (1 pt.)

B) What is the total translational kinetic energy of the seven particles in the tube? (1 pt.)

C) What is the value of the PV product for these particles? (1pt.)

D) In the kinetic molecular theory as developed in class, the PV product of a gas is equal to 2/3 of the total translational kinetic energy. Why is that not also true in this situation (see answers for B and C above). (1 pt.)

2. Explain why it requires more heat to change the temperature of an ideal gas 1 degree at constant pressure than it does at constant volume. (1 pt.)

3. Explain why more heat is required to change the temperature of a diatomic gas 1 degree than does a monatomic gas. (1 pt.)

4. Explain why the temperature of most gases drop when the gas escapes from a high presure container. (1 pt.)

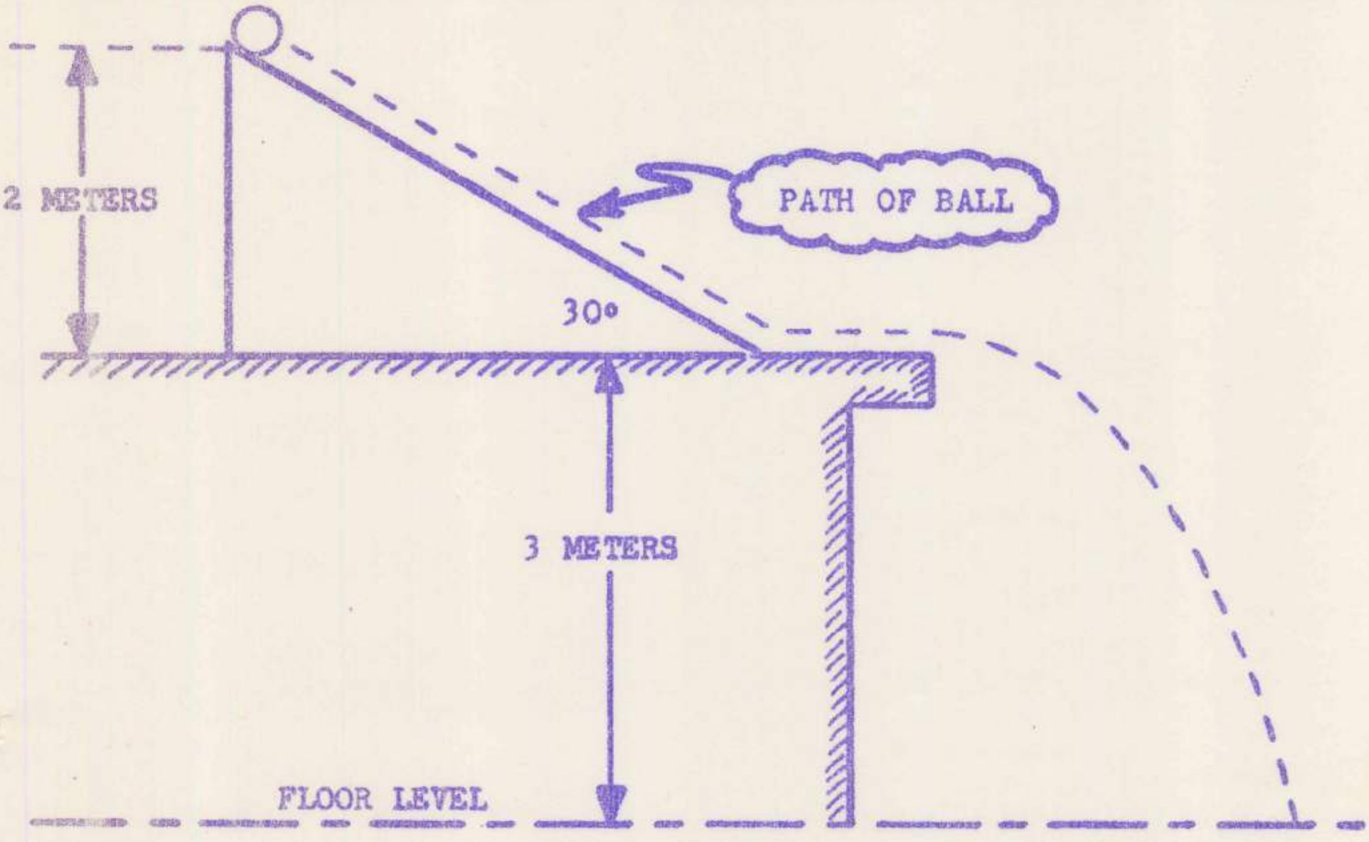
5. What is the ratio of the speed of a hydrogen molecule to the speed of a helium molecule at the same temperature? Atomic Mass Numbers are H = 1 and He = 4. (2 pts.)

6. Discuss one deviation of the behavior of a real gas from the ideal gas behavior developed in the kinetic moleculer theory. (1 pt.)

PSSC PHYSICS QUIZ #_____ Name ____________________

CONSERVATION OF ENERGY Date ____________________

1. A 2 kilogram ball is released from the top of a frictionless plane as shown in the diagram below. What is the speed of the ball when it hits the floor? (3 pts.)

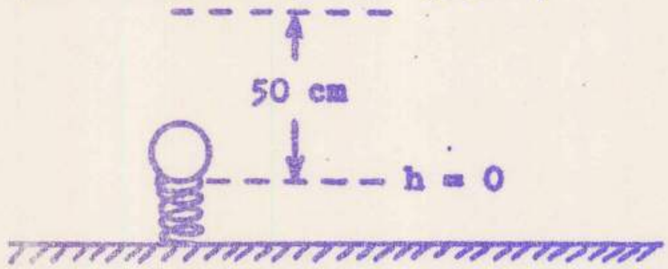


2. A ball with a mass of 1.0 kilogram has a speed of 10 meters per second along a frictionless horizontal floor. The ball runs into a spring bumper with a spring constant of 400 Newton/meter. How far is the spring compressed? (3 pts.)

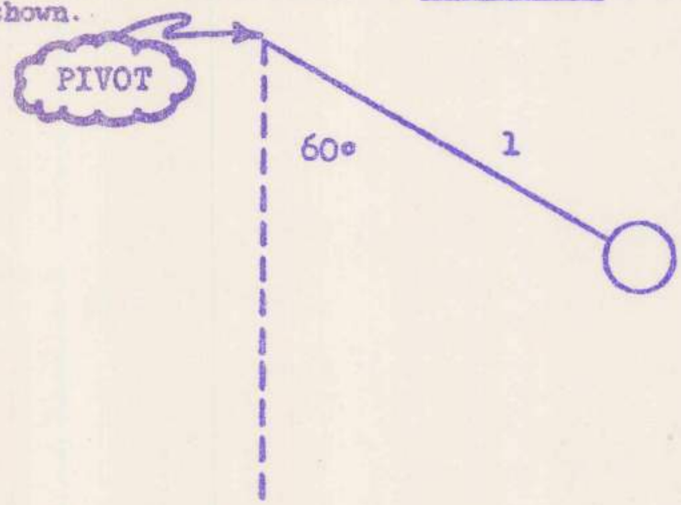
PSSC PHYSICS QUIZ #____ Name ____________________

CONSERVATION OF ENERGY Date ____________________

3. A spring (k = 400 Newton/meter) is compressed 50 centimeters; then a ball is placed on top of the spring (see diagram below). What is the mass of the ball, if it obtains a height of one (1) meter above h = 0 when the ball is shot into the air by releasing the spring. (3 pts.)



4. A pendulum ball has a mass of 5 kilograms and is pulled back to an angle of 60° as shown.



If the length of the pendulum is 160 centimeters, what is the speed of the ball as it passes directly below the pivot point? (1 pt.)

E.P.: Make up the next question for this quiz following the pattern in the above problems. The pattern is contained in the underlined words.

E.P. Answer multiple choice questions on this sheet - must get all correct for extra point.

This is a matching quiz. Each item on the left is to be matched with one on the right.

Atom ( ) 2	(1) To Act
Battery ( ) 12	~~(2)~~ The First Man
Dyne ( ) 13	~~(3)~~ Listerine
Molar Solution ( ) 3	~~(4)~~ What Banks Do with Money
Dew ( )	~~(5)~~ Ethopian
Ion ( )	~~(6)~~ Please Repeat
Watt ( ) 6	~~(7)~~ Device for Cleaning Fish
Polyton ( ) 9	~~(8)~~ Used in Driving
Baritum ( ) 17	~~(9)~~ A Dead Parrot
Complement ( )	~~(10)~~ Food for a Monkey
Gas ( ) 8	(11) A Lie One Likes to Hear
Light Rays ( )	~~(12)~~ Pitcher and Catcher
Lens ( ) 4	~~(13)~~ To Take Sustenance
Liter ( )	(14) Small Salary Increase
Tangent ( ) 5	(15) Bed for a Monkey
Scalar ( ) 7	(16) The Front Side of One's Head
OHM ( ) 18	~~(17)~~ Duty of an Undertaker
Refraction ( ) 19	~~(18)~~ Mexican's House
$Ba(Na)_2$ ( ) 10	~~(19)~~ To Divide Again
Apricot ( )	(20) One Who Conducts

Physics Exp. No. Law of Cons. of Energy Name ____________________

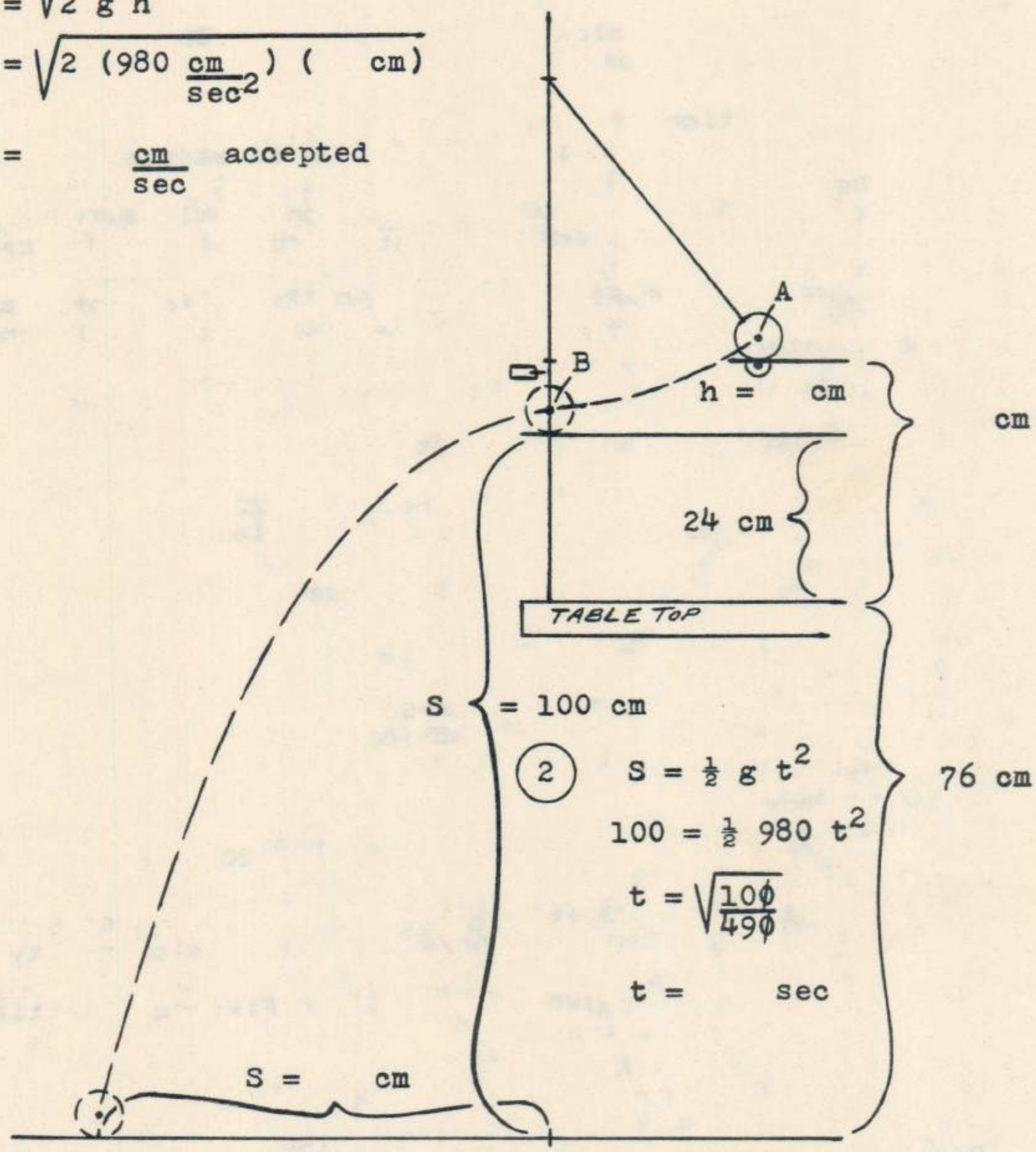
(1) KE at B = PE at A

$$\frac{1}{2}\cancel{m}v^2 = \cancel{m}gh$$

$$v = \sqrt{2gh}$$

$$v = \sqrt{2\left(980\ \frac{cm}{sec^2}\right)(\quad cm)}$$

$$v = \quad \frac{cm}{sec} \text{ accepted}$$



(2) $S = \frac{1}{2}gt^2$

$$100 = \frac{1}{2}\,980\,t^2$$

$$t = \sqrt{\frac{10\cancel{0}}{49\cancel{0}}}$$

$$t = \quad sec$$

(3) $S = vt$

$$v = \frac{S}{t} = \frac{\quad cm}{\quad sec} = \quad \frac{cm}{sec} \text{ exp.}$$

(4) $\frac{\Delta}{\text{accepted}}$ = % error