PHYS 1114, Lecture 5, January 27

Contents:

1° Announcements about TA’s were added to the website:

Announcements

Here special announcements will be posted and below summaries of lectures and notes for exam preparation will be given. It takes time to make the notes, so that I usually run behind.

A few corrections were made in the syllabus. The office numbers of the lab manager (page 1) and the learning assistants (page 4) were misprinted, and the drop dates on page 4 were last year’s.

The TA office hours are in PS 052 and most TA’s should be able to help with physics questions. This free help has started this week. The 1114 TA’s can help with ExpertTA related problems and their times are:

- Mr. Egor Antipov: M 12:00–2:00, W 12:00–2:00
- Mr. Debsuvra Mukhopadhyay: W 11:30–1:30, F 11:30–1:30

Email about ExpertTA, especially technical non-physics questions, should be sent to Mr. Sreekul Rajagopal (Raj for short) at sreekul@okstate.edu. He is the TA assigned to provide technological assistance for both Physics 1114 and 1214. More difficult problems he will pass on to me.

The Learning Assistants are also beginning in PS 210. There are enough sessions, but seating is limited. I had hoped for a better system, but the department chose for you to find out the best time of the week by trial and error. Try to come once a week; there should be no credit for multiple visits in one week. The hours are (R=Thursday):

- Mr. Kazsa Fahrenthold: M 2:30–3:30, T 6:00–7:00, W 12:30–1:30, R 6:00–7:00
- Mr. Kylar Moody: M 3:30–4:30, T 1:00–2:00, W 9:30–10:30, F 9:30–10:30

Your lab TA, and all other 1114 and 2014 lab TA's, can help you if you have problems with your Lab Report. Their office hours in PS 052 will soon be posted on the wall.

Lecture summaries in pdf format:

1. Syllabus and Syllabus Attachment.
2. Lecture 1, January 18, 2017.
Movie: Gravitational Acceleration: Determination of “g”
All freely falling objects are acted upon by gravitational force and accelerate at the same rate (ignoring air resistance).

Part 1: A billiard ball is dropped in front of a 1 meter vertical scale with 10 cm intervals. A stroboscope is used flashing at a constant rate of 17.5 flashes per second, corresponding to a time interval of 0.057 s. The values \( d \) over which the ball has dropped can be read from the video up to \( \pm 1 \) cm; the time values \( t \) are \( 0, 1, \cdots, 8 \) times \( \frac{1}{17.5} \) seconds. Results:

<table>
<thead>
<tr>
<th>17.5 ( t ) (s)</th>
<th>( d ) (cm)</th>
<th>( d_{\text{th}} ) (cm)</th>
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<tbody>
<tr>
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<td>8</td>
<td>101</td>
<td>102</td>
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</tbody>
</table>

\( v_o = 0 \) m/s
\( d \): measured quantity
\( t \): measured quantity
\( g \): unknown
\( d = v_o t + \frac{1}{2}gt^2 = \frac{1}{2}gt^2 \)
\( g = 2d/t^2 \)
\( d_{\text{th}} \): calculated from \( t \), using \( g = 9.8 \) m/s\(^2\)

Part 2: Dropping the ball from a greater height. Now there are three horizontal lines at 0.00 m, 2.00 m and 2.50 m. The last two lines can be used to measure the average velocity at the midpoint. Using a slow motion factor of 9, time in the movie can be converted to real time. There are three methods:
(i) Measuring time to drop the whole distance. This uses the same formulae as part 1.
(ii) Using acceleration \( a = \frac{\text{change in velocity}}{\text{change in time}} \), or in formula 
\[ a = g = \frac{v_f - v_o}{t} \]. Again \( v_o = 0 \). At the midpoint of the
50 cm interval \( \bar{v} = v_{\text{average}} = v_{f(\text{instantaneous})} \) for uniform
acceleration. It can be determined measuring the times
when the ball passes the 2.0 and the 2.5 meter marks.

(iii) Using a third kinematic equation \( v_f^2 = v_o^2 + 2gd \), or also
\[ g = \frac{v_f^2 - v_o^2}{2d} \]. Here \( v_o \) and \( v_f \) are as in part (ii), \( d = 2.25 \text{ m} \).

3° Introduced equations for uniform motion and uniformly
accelerated motion on a line.

4° Discussed vertical motion under the influence of gravity
and the value of \( g = 9.80 \text{ m/s}^2 \), the magnitude of the
downward acceleration due to gravity not too far from the
surface of the Earth.

Ultimately, air friction will become noticeable and a
falling object in air will reach its terminal velocity. But,
unless it is otherwise stated, we will assume that in our
problems we are far from that and that air friction can be
ignored.

(The acceleration due to gravity varies slightly from
\( g = 9.78 \text{ m/s}^2 \) at the equator to \( g = 9.83 \text{ m/s}^2 \) at the poles.
This is due to the rotation of the Earth, which causes the
surface at the equator to move with 1,000 mi/h around
the rotation axis. The resulting centrifugal effect causes
an apparent little outward acceleration at the equator and
it also makes the distance of the equator to the center of
the Earth larger than the two distances from the poles to
the center, as the equator bulges out, resulting in a small
decrease in gravity moving from pole to equator.)
Kinematics of motion on a line

\[
\begin{align*}
\text{position} & \quad x & \text{unit} = \text{m} \\
\text{velocity} & \quad v & \text{unit} = \text{m/s} \\
\text{acceleration} & \quad a & \text{unit} = \text{m/s}^2
\end{align*}
\]

**Average velocity:** \( \bar{v} \),

\[
\bar{v} = \frac{x_f - x_o}{\Delta t}, \quad \Delta t = \text{duration}
\]

Here, \( x_f \) is final position, \( x_o \equiv x_i \) is original/initial position, while \( \Delta t = t_f - t_o \), the difference of final and original time. The Greek capital delta stands for “change in”. Therefore, also

\[
\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_o}{t_f - t_o} = \frac{x_f - x_o}{t} = \frac{x - x_o}{t},
\]

as we often set \( t_o = 0, \ t_f = t \) and \( x_f = x \). Then, \( x - x_o = \bar{v}t \), or

\[
x = x_o + \bar{v}t.
\]

**Uniform motion:** \( v = \bar{v} \) = constant, and

\[
x = x_o + vt.
\]
Uniform acceleration:

\[ a = \bar{a} = \text{average} = \text{constant}, \]

where

\[ \bar{a} = \frac{v_f - v_o}{\Delta t} = \frac{v - v_o}{t} = a. \]

Hence, \( v - v_o = at, \) or \( v = v_o + at. \)

Next we plug this in into the formula for average velocity at constant acceleration, \( \bar{v} = \frac{v_o + v}{2}. \)

\[ \bar{v} = \frac{v_o + v}{2} = \frac{v_o + v_o + at}{2} = v_o + \frac{1}{2}at, \]

\[ x = x_o + \bar{v}t = x_o + (v_o + \frac{1}{2}at)t = x_o + v_o t + \frac{1}{2}at^2. \]

(This derivation will not be required on exams, but you need to remember the final formulas, any way it works best for you.)
Graphical pictures of the equations, in case it is helpful:

**Uniform motion, no acceleration:**

\[ x = v_0 t \]

\[ v = \bar{v} = v_o = \text{constant}, \quad x - x_o = v_o t, \ (\text{with } x_o = 0 \text{ here}). \]

**Uniformly accelerated motion:**

\[ v = v_0 + at \]

\[ a = \bar{a} = a_o = \text{constant}, \quad v = v_o + at, \]

\[ x - x_o = v_o t + \frac{1}{2} at^2, \ (\text{with } x_o = 0 \text{ here}). \]
Sample Problem 1 like on Exam 1

1. Two students leave home to see a movie. First they walk due north for 1.8 km. Then they walk due east for another 1.3 km. After the movie the students want to have a snack at Joe’s. They walk 520 m, roughly in the southwest direction; more precisely they walk with an angle of 42° with respect to due west.
   a) Make a sketch containing all the various displacement vectors and their components in north/south and east/west directions. (If you need more space, you can write “over” and draw your sketch on the back of this page.)

   b) What is the shortest distance between their home and the movie theater?

   c) How much is this in miles? (1 mile is 1760 yard; 1 inch is 2.54 cm; 1 yard is 36 inch.)

   d) What angle does this shortest distance make with respect to due north?

   e) What is the shortest distance between their home and Joe’s?
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   a) Make a sketch containing all the various displacement vectors and their components in north/south and east/west directions.
b) What is the shortest distance between their home and the movie theater?

\[ \sqrt{1.3^2 + 1.8^2} \text{ km} = 2.2 \text{ km} \]

c) How much is this in miles? (1 mile is 1760 yard; 1 inch is 2.54 cm; 1 yard is 36 inch.)

\[ 2.2 \text{ km} \times \frac{1000 \text{ m/km} \times 100 \text{ cm/m}}{1760 \text{ yard/mile} \times 36 \text{ inch/yard} \times 2.54 \text{ cm/inch}} = 1.4 \text{ mile} \]

d) What angle does the shortest distance make with respect to due north?

\[ \arctan \left( \frac{1.3}{1.8} \right) = \tan^{-1} \left( \frac{1.3}{1.8} \right) = 0.63 \text{ rad} = 36^\circ \]

e) What is the shortest distance between their home and Joe’s?

\[ \sqrt{(1.3 \text{ km} - 0.520 \cos 42^\circ \text{ km})^2 + (1.8 \text{ km} - 0.520 \sin 42^\circ \text{ km})^2} \]

\[ = \sqrt{(1.3 \text{ km} - 0.386 \text{ km})^2 + (1.8 \text{ km} - 0.348 \text{ km})^2} \]

\[ = \sqrt{0.91^2 + 1.45^2} \text{ km} = 1.7 \text{ km} \quad (= 1.1 \text{ mile}) \]