AP Physics C Summer Homework.

- This set of problems should be completed during summer break
- If you need help, you can use “Problem Solving Techniques” presentations posted on NJCTL.ORG website
- This work should be completed in a separate paper that will be collected in September
- Summer work will be graded based on 50 points
- With all questions you may contact Mr. Zavorotniy yurzav@bergen.org

1. A bus makes three displacements in the following order:
   1) 38 mi, 48° east of north
   2) 79 mi, 46° west of north; and
   3) 55 mi, south-east
   a. Draw a clear diagram showing all three displacement vectors with respect to horizontal points (north, east, south, and west).

   b. Find the X and Y components of displacement $D_1$.

   c. Find the X and Y components of displacement $D_2$.

   d. Find the X and Y components of displacement $D_3$.

   e. Find the magnitude of the resultant vector.

   f. Find the direction of the resultant vector.
2. A car makes three displacements on the way to the bank. These displacements are then displayed on a graph. Their components are as follows:
   1) $D_1 = (28.8, 18)$
   2) $D_2 = (-4.5, -25.6)$
   3) $D_3 = (10.6, -5.6)$

a. Find the magnitude and the measure of the angle formed by $D_1$.

b. Find the magnitude and the measure of the angle formed by $D_2$.

c. Find the magnitude and the measure of the angle formed by $D_3$.

d. Plot all three vectors on a graph with respect to the x and y coordinates.

e. Determine the magnitude of the resultant vector.

f. Find the angled formed by the resultant vector.
3. An object moves along a straight line and the velocity as a function of time is presented by the above graph.
   a. Find the acceleration of the object for the time intervals: 0-5 s, 5 s-10 s, 10 s-15 s, 15 s-20 s, 20 s-25 s, and 25 s-30 s.
   b. Find the traveled distance of the object for the entire trip.
   c. Find the displacement of the object for the entire trip.
   d. Graph the position and acceleration of the object between t = 0 and t = 30 s.

4. A helicopter moves straight up with a constant velocity of 8 m/s. When the helicopter is 120 m above the ground level the pilot drops a package. Ignore air resistance.
   a. Find the position relative to the ground, and the velocity of the package 5 s after it was dropped.
   b. How long will the package stay in the air?
   c. What will the velocity of the package be just before it strikes the ground?
   d. What is the maximum height the package reaches?
   e. Graph the following y(t), v_y(t), a_y(t) after the package is dropped.
5. A boy dives off a cliff with a running horizontal velocity of 8.60 m/s. The distance from the edge of the cliff to the surface of the lake is 12.0 m.

a. How much time will it take the boy to fall from the edge of the cliff to the surface of water?
b. How far from the cliff will he strike the surface of water?
c. What is the landing velocity?
d. Graph the horizontal and vertical components of the velocity.

6. A cannon ball is fired from a cannon located at the edge of 34.0 m tall cliff with an initial velocity of 540.0 m/s at an angle 42.0° above the horizontal.

a. How much time is required for the cannon ball to reach the ground?
b. How far from the cliff will the cannon ball strike the ground?
c. What is the maximum height, above the ground, reached by the cannon ball?
d. What is the landing velocity of the cannon ball (magnitude and direction)?
e. Draw x(t), y(t), v_x(t), v_y(t), a_x(t), and a_y(t) for the motion of the cannon ball.
7. A block of mass $m$ is placed on an inclined surface that makes an angle $\theta$ above the horizontal. A constant horizontal force $F$ is applied on the block, causing the block to accelerate up the incline. The coefficient of kinetic friction between the block and the plane is $\mu$. Present all answers in terms of $m$, $\theta$, $\mu$, $F$ and $g$.

   a. On the diagram below, show all the applied forces on the block when it moves up the plane.

   ![Diagram](image)

   b. Determine the normal force applied on the block by the surface.

   c. Determine the block’s acceleration as it moves up the incline.

   d. If the block slides up at a constant speed, what is the value of force $F$?

   e. If the block slides down at a constant speed, what is the value of force $F$?
8. Block B, with a mass $M_B$, rests on the top of block A, with a mass $M_A$, which is placed on a horizontal tabletop. A light string attached to block A passes over a frictionless and massless pulley and is connected to block C which is suspended from the pulley. The coefficient of kinetic friction between all the surfaces is $\mu_k$ and the coefficient of static friction is $\mu_s$.

a. Find the largest mass $M_C$ of block C that will not allow the two blocks to slide on the tabletop; assume the blocks don’t slip on each other.

b. Find the minimum value of mass $M_C$ that block C can have so the blocks will move at a constant non zero speed when the system is released, with block B remaining at the same relative position on block A.

c. Find the maximum value of mass $M_c$ that block A and B move together.
9. A block with mass $m$ is released from rest and slides a distance $d$ down a frictionless inclined plane with an angle $\theta$ above the horizontal. At the end of distance $d$ the block strikes a spring of spring constant $K$.

   a. Find the speed of the block just before it hits the spring.

   b. Find the maximum compression $x$ of the spring in terms of $k$, $m$, $d$, $\theta$ and $g$.

   c. Determine the location, with respect to where the block first made contact with the spring, where the speed of the block reaches its maximum value after the collision.

   d. Determine the maximum speed of the block after the collision with the spring.

10. A block of mass $m$ is released from rest at the top of a frictionless sphere of radius $R$. The sphere does not move.

   a. At what distance $h$ from the ground level does the block leave the surface of the sphere?

   b. What is the speed of the block at the location where it leaves the sphere?

   c. What is the centripetal acceleration of the block at the location where it leaves the sphere?

   d. What is the tangential acceleration of the block at the location where it leaves the sphere?
11. A rifle bullet with a mass \( m = 9.00 \text{ g} \) strikes and embeds into a wooden block with a mass \( M = 1.00 \text{ kg} \) that rests on a frictionless, horizontal surface and is attached to a spring. After the collision the spring compresses by a distance of 18.0 cm. Assuming the spring obeys Hooke’s Law and has a spring constant \( k = 300 \text{ N/m} \):

a. Find the velocity of the bullet-block system after the collision.
b. Find the velocity of the bullet before the collision.
c. Find the energy loss due to the collision.
d. Find the period of oscillation of the bullet-block-spring system.

12. A pellet with a mass \( m \) is fired with an initial speed \( v_o \) into a wooden block of mass \( M \) suspended at the end of a light string of length \( L \). After the pellet strikes the block, it becomes embedded in the block and caused the block to move to the right and the string to deflect from the vertical by an angle \( \theta \).

a. Determine the velocity of the block after the collision.
b. Determine the change in the kinetic energy of the system during the collision.
c. Determine the angular displacement of the string.
d. What is the initial speed of the pellet if the string deflects by \( \theta = 90^\circ \)?
13. A solid uniform sphere of mass $M$ and radius $R$ rolls without slipping at a constant speed $v_o$, when it enters an inclined section of the surface with an angle $\theta$ above the horizontal. The moment of inertia of the sphere is $I = \frac{2}{5}MR^2$.

- a. Determine the translational kinetic energy of the sphere when it is rolling on the horizontal section of the surface.
- b. Determine the rotational kinetic energy of the sphere when it is rolling on the horizontal section of the surface.
- c. Determine the linear acceleration of the sphere when it is rolling up the inclined section.
- d. Determine the friction force acting on the sphere when it is rolling up the inclined section.
- e. Determine the maximum distance along the inclined section that the sphere can reach.
14. A thin, uniform rod of mass M and length L is initially at rest on a frictionless horizontal tabletop. A small sphere, m moves perpendicularly toward the rod with an initial velocity, $v_o$, and strikes the rod at the bottom end. After the collision the sphere moves in the opposite direction with a velocity $-\frac{v_o}{3}$. The moment of inertia of the rod with respect to its center of mass is $I = \frac{1}{12} ML^2$.

a. Is the linear momentum of the system conserved? Explain.
b. Is the angular momentum of the system conserved? Explain.
c. Find the velocity of the center of mass of the rod after the collision.
d. Find the angular velocity of the rod after the collision.
15. A satellite of mass 2,000 kg is in an elliptical orbit about the Earth. When the satellite reaches point A, which is the closest point to the Earth, its orbital radius is $1.2 \times 10^7$ m and its orbital velocity is $7.1 \times 10^3$ m/s ($M_E = 6.0 \times 10^{24}$ kg and $R_E = 6.4 \times 10^6$ m).

a. Determine the total mechanical energy of the satellite at point A, assuming that the gravitational potential energy is zero at an infinite distance from the Earth.

b. Determine the angular momentum of the satellite at point A.

c. What is the minimum speed of the satellite at point A in order to escape from Earth?

When the satellite reaches point B, which is the farthest point from the Earth, its orbital radius is $3.6 \times 10^7$ m.

d. Determine the speed of the satellite at point B.

16. A satellite is placed into a circular orbit around Mars, which has a mass $M = 6.4 \times 10^{23}$ kg and radius $R = 3.4 \times 10^6$ m.

a. Derive an expression for the orbital speed assuming that the orbital radius is $R$.

b. Derive an expression for the orbital period assuming that the orbital radius is $R$.

c. The orbital period of the satellite can be synchronized with Mars’ rotation, whose period is 24.6 hours. Determine the required orbital radius for this to occur.

d. Determine the escape speed from the surface of Mars.
17. An experiment to measure the acceleration due to gravity $g$ was conducted in a physics lab. Students were using a simple pendulum, meter stick, and stopwatch. The pendulum consisted of a ball of mass $m$ at the end of a string of length $L$. During the experiment, the students were changing the length of the string and recording the time for ten complete oscillations. The data are shown below.

<table>
<thead>
<tr>
<th>L (m)</th>
<th>$t_{10}$ (s)</th>
<th>T (s)</th>
<th>$T^2$ (s$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>8.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>12.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>15.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>17.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>20.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Calculate the period and the square of the period for each trial and enter these results in the table above. Use a reasonable number of significant figures.

b. On the graph below, plot the period squared versus length using an appropriate x and y scale. Draw the best-fit line for this data.

c. Assuming that the pendulum undergoes SHM according to your best-fit line, determine the value of the acceleration due to gravity. Explain your answer.

d. If the experiment was performed in an elevator that is accelerating upward, how would it change the answer to part (c)? Explain.
18. An elastic spring with is placed on a horizontal platform. A pan of mass $M$ is attached to the top end of the spring, compressing it a distance $d$. A piece of clay is dropped from a height $h$ onto the pan. The piece of clay strikes the pan and sticks to it.
   a. What is the speed of the clay just before it hits the pan?
   b. What is the speed of the pan just after the clay strikes it?
   c. What is the period of oscillation?
   d. How much is the spring stretched at the moment when the speed of the pan is a maximum?
   e. If a smaller in diameter spring is placed inside the first one so two springs can support the pan, how would it change the period of oscillations?