# 2017 AP Physics Summer Work

Welcome to AP Physics!

This class is designed to be taught at a college level and pace. I am hoping that by taking AP Physics in high school that you will feel prepared for the AP Physics 1 Test (algebra based) and for physics in college, which depending on what you decide to go into will be algebra based (pre-med majors) or calculus based (engineering students). Success in this class will require logic, math, and problem solving skills. I will do my best to make myself available to help you.

The class is VERY conceptual in nature as the AP Physics Test was re-worked three years ago to make this the case. Because a student might be able to work through a very complicated equation for physics and not understand any of the physics behind it, the class was reworked and is now about understanding physics. You're allowed a calculator on all of the AP Physics 1 test but it may not help you that much. A lot of times figuring out what the question is asking and deciding what to calculate is by far more difficult than the calculation itself. You already have a great start having taken a year of physics at Milan High School. AP Physics aims to give you a more sophisticated understanding of that material and to expand on what you already know.

**Summer Contact Info.:**
I am hoping that you will work on the summer work throughout the summer, and I am willing to help over email. Also, I will be available to meet throughout the summer as I am at the high school quite a bit due to coaching tennis. I will start an email group so that I can communicate with the class as a whole when necessary. I will set up a time for the class to meet at the school a few times over the summer if people are interested in meeting.

**Text Book**
Come by and pick up a copy of the text, Cutnell and Johnson which is used as a reference and contains reading that will help for the summer work.

**Video Resource**
If you find concepts tough to understand or if you just want a more complete understanding of something from class. I really appreciate the "Doc Physics" videos on Youtube. He is an amazing AP Physics teacher and this is an excellent resource that you need to take advantage of. Another resource that my students have liked to use are the "Flippin' Physics" videos on Youtube. These are especially helpful to review a unit or review before the test in May.

**Showing work and the AP Physics test**.

There are two contrary ideas that you must understand to succeed on the AP physics test. You must be able to move and work quickly as it's a very fast test. This is especially true that on the multiple choice portion of the test when you don't have to show work. If you're not a fast test taker, you must practice this skill!

On the short answer part of the test, you must show your understanding with both calculation and explanation. This means that not only must you show your work (calculation) but you must explain why it's the correct response to the question with words and diagrams.

The default method in this class will be to show our work for every calculation unless instructed not to. I also recommend always drawing the situation to gain a deeper insight into the problem. If you feel that I am asking too much for you to show your work constantly, please find another AP Physics class to join. Assignments will be worth zero points if you don't show your work. When it comes time to take practice AP multiple choice tests in class, we will sometimes ignore this rule and move as quickly as possible.

**Summer Work:**

I have went ahead and printed off two packets for you. One packet contains review guides and tests for the first three units (Vectors and Units, 1d Kinematics, and 2d Kinematics). I don't plan on retesting these units in the fall, but we will do some review of these concepts with labs in class.

The reviews and tests from the first three units are due on the first day. You must show your work on the review guides and tests, even the multiple choice questions.

Use a separate sheet of paper for multiple choice questions preferably unlined (the official paper of AP Physics). To help with these tests and reviews, I have attached answers from the reviews and some of the test questions in a separate packet. I generally grade summer work based on both effort and accuracy as I know some of the problems are very difficult. You can always begin a difficult problem by drawing the situation and writing down the known variables.

Have a great summer! Contact me with any questions.

Mr. Rodriguez
rodriguezn@milanareaschools.org

# AP® PHYSICS 1 TABLE OF INFORMATION

| CONSTANTS AND CONVERSION FACTORS | |
|---|---|
| Proton mass, $m_p = 1.67 \times 10^{-27}$ kg | Electron charge magnitude, $e = 1.60 \times 10^{-19}$ C |
| Neutron mass, $m_n = 1.67 \times 10^{-27}$ kg | Coulomb's law constant, $k = 1/4\pi\varepsilon_0 = 9.0 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2$ |
| Electron mass, $m_e = 9.11 \times 10^{-31}$ kg | Universal gravitational constant, $G = 6.67 \times 10^{-11}\ \text{m}^3/\text{kg}\cdot\text{s}^2$ |
| Speed of light, $c = 3.00 \times 10^8$ m/s | Acceleration due to gravity at Earth's surface, $g = 9.8\ \text{m/s}^2$ |

| UNIT SYMBOLS | | | | |
|---|---|---|---|---|
| | meter, m | kelvin, K | watt, W | degree Celsius, °C |
| | kilogram, kg | hertz, Hz | coulomb, C | |
| | second, s | newton, N | volt, V | |
| | ampere, A | joule, J | ohm, Ω | |

| PREFIXES | | |
|---|---|---|
| **Factor** | **Prefix** | **Symbol** |
| $10^{12}$ | tera | T |
| $10^{9}$ | giga | G |
| $10^{6}$ | mega | M |
| $10^{3}$ | kilo | k |
| $10^{-2}$ | centi | c |
| $10^{-3}$ | milli | m |
| $10^{-6}$ | micro | μ |
| $10^{-9}$ | nano | n |
| $10^{-12}$ | pico | p |

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES

| $\theta$ | 0° | 30° | 37° | 45° | 53° | 60° | 90° |
|---|---|---|---|---|---|---|---|
| $\sin\theta$ | 0 | $1/2$ | $3/5$ | $\sqrt{2}/2$ | $4/5$ | $\sqrt{3}/2$ | 1 |
| $\cos\theta$ | 1 | $\sqrt{3}/2$ | $4/5$ | $\sqrt{2}/2$ | $3/5$ | $1/2$ | 0 |
| $\tan\theta$ | 0 | $\sqrt{3}/3$ | $3/4$ | 1 | $4/3$ | $\sqrt{3}$ | $\infty$ |

The following conventions are used in this exam.

I. The frame of reference of any problem is assumed to be inertial unless otherwise stated.

II. Assume air resistance is negligible unless otherwise stated.

III. In all situations, positive work is defined as work done on a system.

IV. The direction of current is conventional current: the direction in which positive charge would drift.

V. Assume all batteries and meters are ideal unless otherwise stated.

# AP® PHYSICS 1 EQUATIONS

## MECHANICS

$v_x = v_{x0} + a_x t$

$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$

$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$

$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$

$|\vec{F}_f| \le \mu |\vec{F}_n|$

$a_c = \frac{v^2}{r}$

$\vec{p} = m\vec{v}$

$\Delta \vec{p} = \vec{F} \Delta t$

$K = \frac{1}{2} m v^2$

$\Delta E = W = F_{\parallel} d = Fd\cos\theta$

$P = \frac{\Delta E}{\Delta t}$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

$\omega = \omega_0 + \alpha t$

$x = A\cos(2\pi f t)$

$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$

$\tau = r_{\perp} F = rF\sin\theta$

$L = I\omega$

$\Delta L = \tau \Delta t$

$K = \frac{1}{2} I \omega^2$

$|\vec{F}_s| = k|\vec{x}|$

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

$\rho = \frac{m}{V}$

$\Delta U_g = mg\Delta y$

$T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{\ell}{g}}$

$|\vec{F}_g| = G\frac{m_1 m_2}{r^2}$

$\vec{g} = \frac{\vec{F}_g}{m}$

$U_G = -\frac{G m_1 m_2}{r}$

$a$ = acceleration
$A$ = amplitude
$d$ = distance
$E$ = energy
$f$ = frequency
$F$ = force
$I$ = rotational inertia
$K$ = kinetic energy
$k$ = spring constant
$L$ = angular momentum
$\ell$ = length
$m$ = mass
$P$ = power
$p$ = momentum
$r$ = radius or separation
$T$ = period
$t$ = time
$U$ = potential energy
$V$ = volume
$v$ = speed
$W$ = work done on a system
$x$ = position
$y$ = height
$\alpha$ = angular acceleration
$\mu$ = coefficient of friction
$\theta$ = angle
$\rho$ = density
$\tau$ = torque
$\omega$ = angular speed

## ELECTRICITY

$|\vec{F}_E| = k\left|\frac{q_1 q_2}{r^2}\right|$

$I = \frac{\Delta q}{\Delta t}$

$R = \frac{\rho \ell}{A}$

$I = \frac{\Delta V}{R}$

$P = I\Delta V$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

$A$ = area
$F$ = force
$I$ = current
$\ell$ = length
$P$ = power
$q$ = charge
$R$ = resistance
$r$ = separation
$t$ = time
$V$ = electric potential
$\rho$ = resistivity

## WAVES

$\lambda = \frac{v}{f}$

$f$ = frequency
$v$ = speed
$\lambda$ = wavelength

## GEOMETRY AND TRIGONOMETRY

Rectangle
$A = bh$

Triangle
$A = \frac{1}{2} bh$

Circle
$A = \pi r^2$
$C = 2\pi r$

Rectangular solid
$V = \ell w h$

Cylinder
$V = \pi r^2 \ell$
$S = 2\pi r \ell + 2\pi r^2$

Sphere
$V = \frac{4}{3}\pi r^3$
$S = 4\pi r^2$

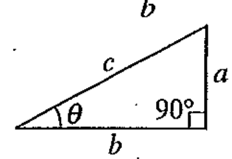
$A$ = area
$C$ = circumference
$V$ = volume
$S$ = surface area
$b$ = base
$h$ = height
$\ell$ = length
$w$ = width
$r$ = radius

Right triangle
$c^2 = a^2 + b^2$

$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$



MHS 2009 AP Physics - Unit, measurement, & vectors Quiz

Name: Date:

1) 7625 cm = ________ km

2) $4\times10^{-4}$ Mg = ________ g

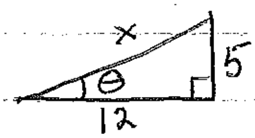
3) What is the base unit for time?

4) 27 mph = ________ m/s

3.28 ft = 1 m
5280 ft = 1 mile

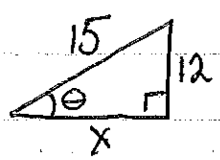
5) Given that 42 smurfs = 1 snork; 1 snork = 71 Azraels; & 12 Azraels = 5 Gargamels...
How many gargamels are equal to 31 smurfs?

6)



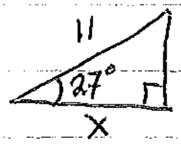

x = ____ θ = ____

7)



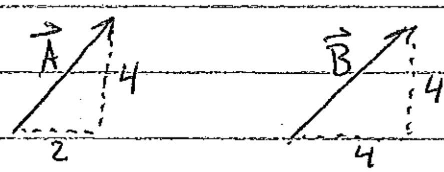

x = ____ θ = ____

8)




Describe what you would do to find the length of side x.

9) You walk 11 m east, then go 17 m North. ⓐ Draw your path. ⓑ How far are you from where you started? ⓒ What direction (including angle) are you from east?

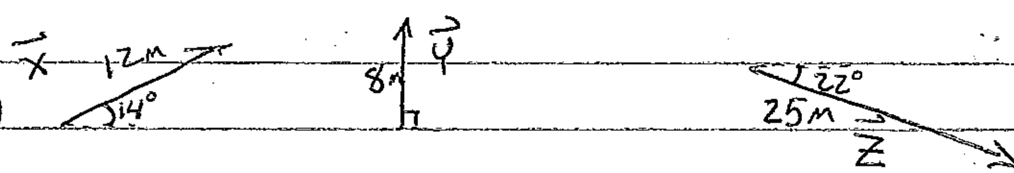
10) 


$\vec{A} + \vec{B} = \vec{C}$

ⓐ Draw $\vec{C}$

ⓑ What are the X & Y components of $\vec{C}$?

ⓒ What angle does $\vec{C}$ make with the x-axis?

11) 


Draw the resultant of $\vec{X} + \vec{Y} + \vec{Z}$.

What is the resultant's magnitude?

What angle does the resultant make with the x-axis?

AP Physics Units, Vectors, and Conversion Quiz

Name ______________________________ Date ________

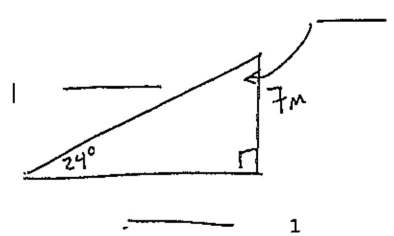
1. The base unit for length is the: ______________________
2. The base unit for mass is the: __________ Hint : not "grams"
3. The base unit for time is the: ______________________
4. 250 nm = ____________ m
5. 65.54 km = ____________ mm
6. $4.5 * 10^6$ mL = ___________ L

1 in = 2.54 cm　　1609 m = 1 mi　　1 L = 0.264 gal　　1 yr = 365 days

1 m = 3.281 ft　　1.609 km = 1 mi　　2.2 lbs = 1 kg　　1 day = 24 hrs

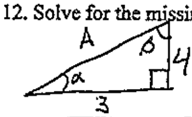
[redacted] #7. Skip

8. 88 lbs = __________ kg
9. 224 in = _____ m
10. $3.0 * 10^8$ L/yr = ________ gal/s
11. Solve for the missing sides and angles of the following triangle:



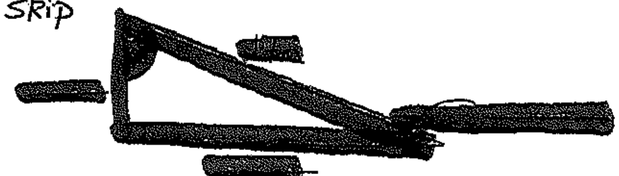



12. Solve for the missing sides and angles of the following triangle: A ______ α ______ β ______

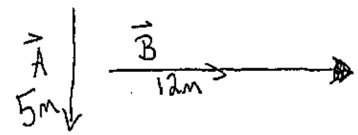



[redacted]:

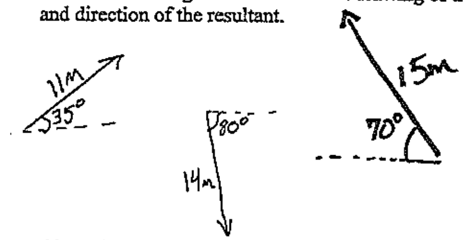
#13. Skip



14. Add the following vectors. Include a drawing of the resultant. List the magnitude and direction of the resultant.




15. Add the following vectors. Include a drawing of the resultant. List the magnitude and direction of the resultant.




Given that the following variables represent values consistent with the following units, which of the equations are consistent with regards to units on each side of the equals sign.

x - meters (m)
v – meters per second (m/s)
t – seconds (s)
a – meters per second squared ($m/s^2$)

16. x = vt　　consistent / inconsistent



Over →

17. $v = at + \frac{1}{2} a t^3$ consistent / inconsistent

18. $v^3 = 2 a x^2$ consistent / inconsistent

Which of the following are vectors?

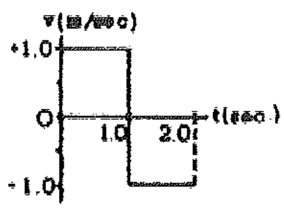
19. Time yes / no

20. force yes / no

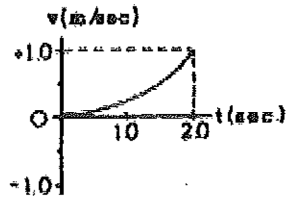
1. A car travels 30 miles at an average speed of 60 miles per hour and then 30 miles at an average speed of 30 miles per hour. The average speed the car over the 60 miles is
(A) 35 m.p.h. (B) 40 m.p.h. (C) 45 m.p.h. (D) 10 m.p.h. (E) 53 m.p.h.

Questions 2 – 4 relate to two particles that start at $x = 0$ at $t = 0$ and move in one dimension independently of one another. Graphs, of the velocity of each particle versus time are shown below

Particle A



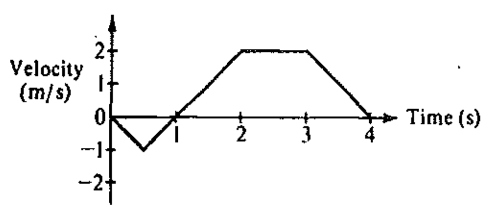

Particle B




2. Which particle is farthest from the origin at $t = 2$ seconds.
(A) A (B) B (C) they are in the same location at $t = 2$ seconds (D) They are the same distance from the origin, but in opposite directions (E) It is not possible to determine

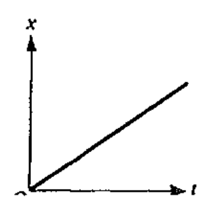
3. Which particle moves with constant non-zero acceleration?
(A) A (B) B (C) both A and B (D) neither A nor B (E) It is not possible to determine

4. Which particle is in its initial position at $t = 2$ seconds?
(A) A (B) B (C) both A and B (D) neither A nor B (E) It is not possible to determine




5. The graph above shows the velocity versus time for an object moving in a straight line. At what time after $t = 0$ does the object again pass through its initial position?
(A) Between 0 and 1 s (B) 1 s (C) Between 1 and 2 s (D) 2 s (E) Between 2 and 3 s

6. A body moving in the positive x direction passes the origin at time $t = 0$. Between $t = 0$ and $t = 1$ second, the body has a constant speed of 24 meters per second. At $t = 1$ second, the body is given a constant acceleration of 6 meters per second squared in the negative x direction. The position x of the body at $t = 11$ seconds is
(A) + 99m (B) + 36m (C) – 36 m (D) – 75 m (E) – 99 m

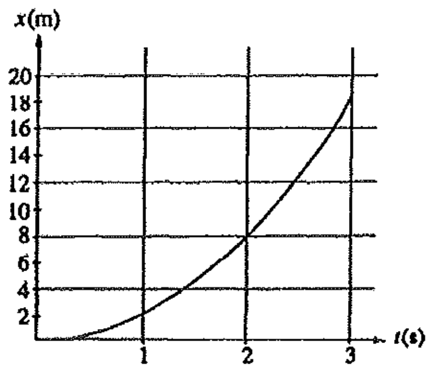



7. The displacement, x, of an object moving along the x-axis is shown above as a function of time, t. The acceleration of this object must be
(A) zero (B) constant but not zero (C) increasing (D) decreasing (E) equal to g

10. A truck traveled 400 meters north in 80 seconds, and then it traveled 300 meters east in 70 seconds. The magnitude of the average velocity of the truck was most nearly
(A) 1.2 m/s (B) 3.3 m/s (C) 4.6 m/s (D) 6.6 m/s (E) 9.3 m/s

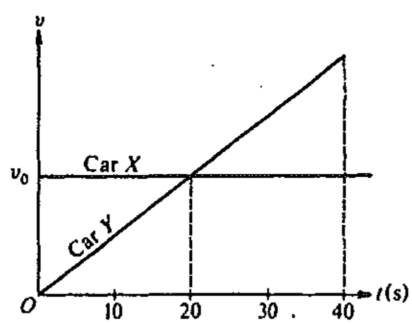
12. An object is released from rest on a planet that has no atmosphere. The object falls freely for 3.0 meters in the first second. What is the magnitude of the acceleration due to gravity on the planet?
(A) 1.5 m/s² (B) 3.0 m/s² (C) 6.0 m/s² (D) 10.0 m/s² (E) 12.0 m/s²

16. A ball is thrown straight up in the air. When the ball reaches its highest point, which of the following is true?
(A) It is in equilibrium. (B) It has zero acceleration. (C)It has maximum momentum
(D) It has maximum kinetic energy. (E) None of the above




17. The graph above represents position x versus time t for an object being acted on by a constant force. The average speed during the interval between 1 s and 2 s is most nearly
(A) 2 m/s (B) 4 m/s (C) 5 m/s (D) 6 m/s (E) 8 m/s

Questions 19 – 20

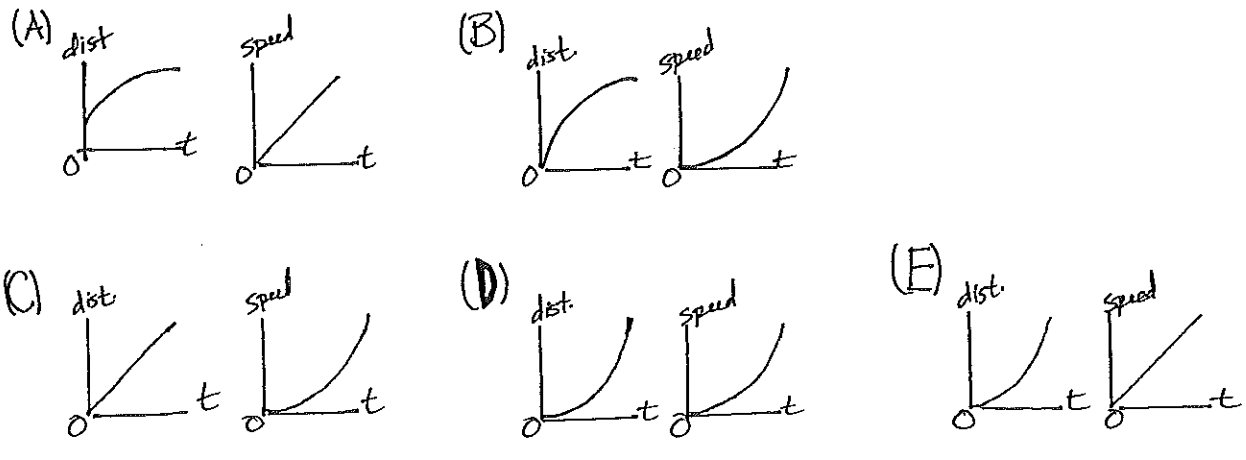



At time t = 0, car X traveling with speed $v_0$ passes car Y which is just starting to move. Both cars then travel on two parallel lanes of the same straight road. The graphs of speed $v$ versus time t for both cars are shown above.

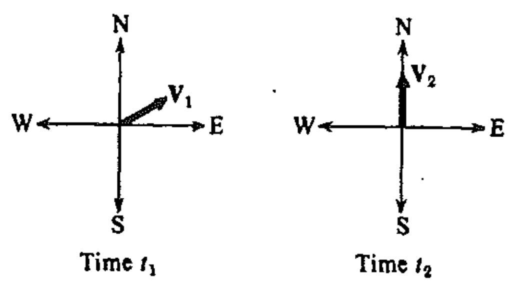
19. Which of the following is true at time t = 20 seconds?
(A) Car Y is behind car X. (B) Car Y is passing car X. (C) Car Y is in front of car X.
(D) Both cars have the same acceleration. (E) Car X is accelerating faster than car Y.

20. From time t = 0 to time t = 40 seconds, the areas under both curves are equal. Therefore, which of the following is true at time t = 40 seconds?
(A) Car Y is behind car X. (B) Car Y is passing car X. (C) Car Y is in front of car X.
(D) Both cars have the same acceleration. (E) Car X is accelerating faster than car Y.

21. Which of the following pairs of graphs shows the distance traveled versus time and the speed versus time for an object uniformly accelerated from rest?




22. An object released from rest at time t = 0 slides down a frictionless incline a distance of 1 meter during the first second. The distance traveled by the object during the time interval from t = 1 second to t = 2 seconds is
(A) 1 m (B) 2 m (C) 3 m (D) 4 m (E) 5 m



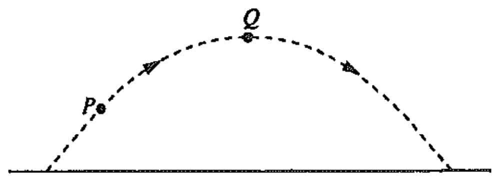

25. Vectors $V_1$ and $V_2$ shown above have equal magnitudes. The vectors represent the velocities of an object at times $t_1$, and $t_2$, respectively. The average acceleration of the object between time $t_1$ and $t_2$ was
(A) zero (B) directed north (C) directed west (D) directed north of east (E) directed north of west

27. In the absence of air friction, an object dropped near the surface of the Earth experiences a constant acceleration of about 9.8 m/s$^2$. This means that the
(A) speed of the object increases 9.8 m/s during each second
(B) speed of the object as it falls is 9.8 m/s
(C) object falls 9.8 meters during each second
(D) object falls 9.8 meters during the first second only
(E) rate of change of the displacement with respect to time for the object equals 9.8 m/s$^2$

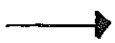
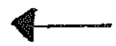
28. A 500kilogram sports car accelerates uniformly from rest, reaching a speed of 30 meters per second in 6 seconds. During the 6 seconds, the car has traveled a distance of
(A) 15 m (B) 30 m (C) 60 m (D) 90 m (E) 180 m

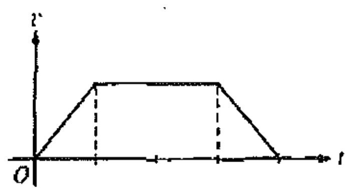
30. An object is shot vertically upward into the air with a positive initial velocity. Which of the following correctly describes the velocity and acceleration of the object at its maximum elevation?

| | Velocity | Acceleration |
|---|---|---|
| (A) | Positive | Positive |
| (B) | Zero | Zero |
| (C) | Negative | Negative |
| (D) | Zero | Negative |
| (E) | Positive | Negative |

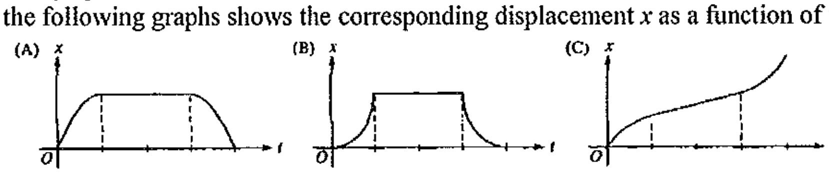



32. A ball is thrown and follows a parabolic path, as shown above. Air friction is negligible. Point Q is the highest point on the path. Which of the following best indicates the direction of the acceleration, if any, of the ball at point Q?

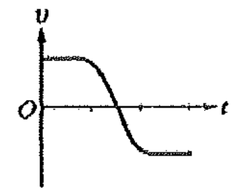
(A)  (B)  (C)  (D)  (E) No acceleration of the ball at point Q.



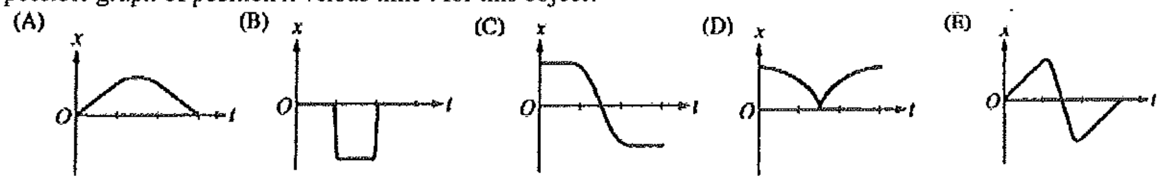

34. The graph above shows the velocity $v$ as a function of time $t$ for an object moving in a straight line. Which of the following graphs shows the corresponding displacement $x$ as a function of time $t$ for the same time interval?



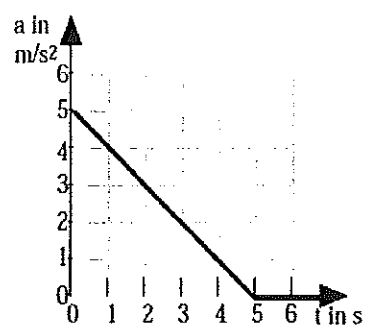

35. An object is dropped from rest from the top of a 400 m cliff on Earth. If air resistance is negligible, what is the distance the object travels during the first 6 s of its fall?
(A) 30 m (B) 60 m (C) 120 m (D) 180 m (E) 360 m



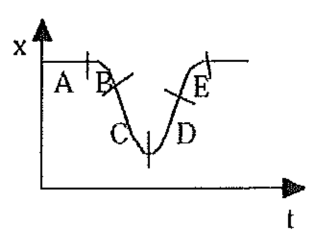

37. The graph above shows velocity v versus time t for an object in linear motion. Which of the following is a possible graph of position x versus time t for this object?




*38. A student is testing the kinematic equations for uniformly accelerated motion by measuring the time it takes for lightweight plastic balls to fall to the floor from a height of 3 m in the lab. The student predicts the time to fall using $g$ as 9.80 m/s$^2$ but finds the measured time to be 35% greater. Which of the following is the most likely cause of the large percent error?
(A) The acceleration due to gravity is 70% greater than 9.80 m/s$^2$ at this location.
(B) The acceleration due to gravity is 70% less than 9.80 m/s$^2$ at this location.
(C) Air resistance increases the downward acceleration.
(D) The acceleration of the plastic balls is not uniform.
(E) The plastic balls are not truly spherical.

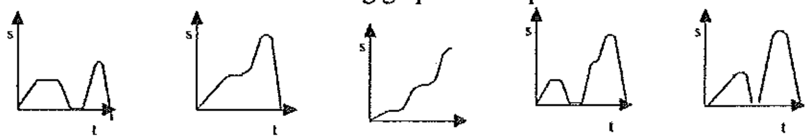



*40. Starting from rest at time t = 0, a car moves in a straight line with an acceleration given by the accompanying graph. What is the speed of the car at t = 3 s?
(A) 1.0 m/s (B) 2.0 m/s (C) 6.0 m/s (D) 10.5 m/s (E) 12.5 m/s




43. The graph above is a plot of position versus time. For which labeled region is the velocity positive and the acceleration negative?
(A) A (B) B (C) C (D) D (E) E

44. A child left her home and started walking at a constant velocity. After a time she stopped for a while and then continued on with a velocity greater than she originally had. All of a sudden she turned around and walked very quickly back home. Which of the following graphs best represents the distance versus time graph for her walk?



(A) (B) (C) (D) (E)

*46. A child tosses a ball directly upward. Its total time in the air is *T*. Its maximum height is *H*. What is its height after it has been in the air a time *T*/4? Neglect air resistance.

(A) H/4 (B) H/3 (C) H/2 (D) 2H/3 (E) 3H/4

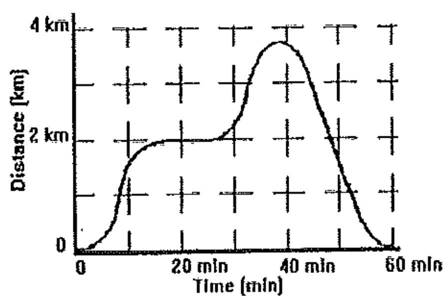
47. A whiffle ball is tossed straight up, reaches a highest point, and falls back down. Air resistance is not negligible. Which of the following statements are true?

I. The ball's speed is zero at the highest point.
II. The ball's acceleration is zero at the highest point.
III. The ball takes a longer time to travel up to the highest point than to fall back down.

(A) I only (B) II only (C) I & II only (D) I & III only (E) I, II, & III

48. A truck driver travels three-fourths the distance of his run at one velocity ($v$) and then completes his run at one half his original velocity ($\frac{1}{2}v$). What was the trucker's average speed for the trip?

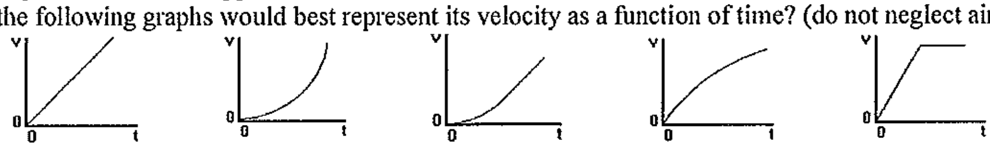
(A) $0.85v$ (B) $0.80v$ (C) $0.75v$ (D) $0.70v$ (E) $0.65v$




49. Above is a graph of the distance vs. time for car moving along a road. According the graph, at which of the following times would the automobile have been accelerating positively?

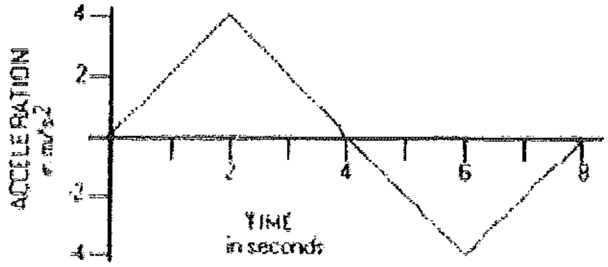
(A) 0, 20, 38, & 60 min. (B) 5, 12, 29, & 35 min. (C) 5, 29, & 57 min. (D) 12, 35, & 41 min.
(E) at all times from 0 to 60 min

50. A large beach ball is dropped from the ceiling of a school gymnasium to the floor about 10 meters below. Which of the following graphs would best represent its velocity as a function of time? (do not neglect air resistance)



(A) (B) (C) (D) (E)

Questions 51 – 52
A car starts from rest and accelerates as shown in the graph below.

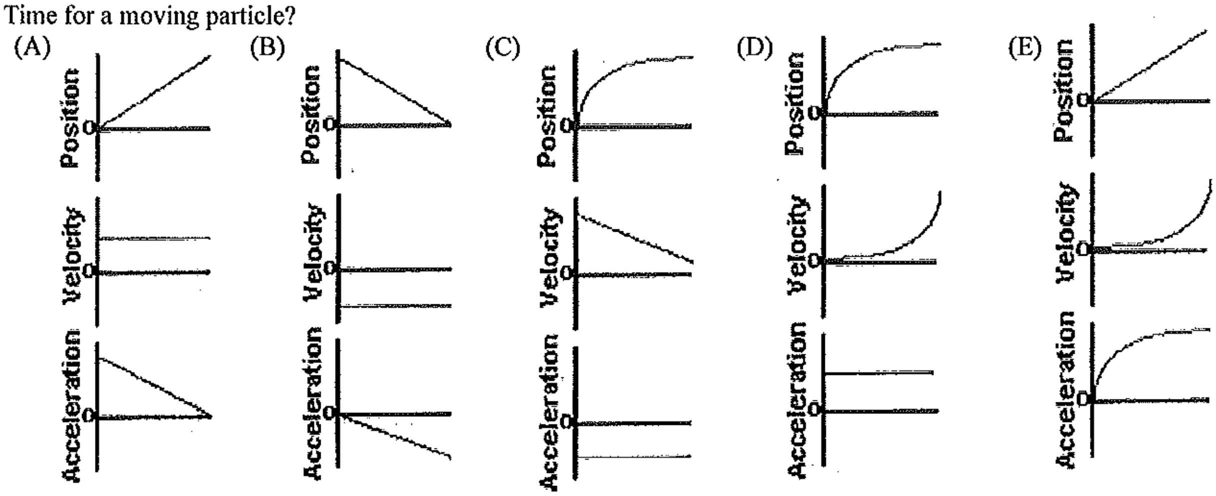



51. At what time would the car be moving with the greatest velocity?
(A) 0 seconds (B) 2 seconds (C) 4 seconds (D) 6 seconds (E) 8 seconds

*52. At what time would the car be farthest from its original starting position?
(A) 0 seconds (B) 2 seconds (C) 4 seconds (D) 6 seconds (E) 8 seconds

53. A ball is dropped 1.0 m to the floor. If the speed of the ball as it rebounds from the floor is 75% of the speed at which it struck the floor, how high will the ball rise?
(A) 0.28 m (B) 0.35 m (C) 0.56 m (D) 0.75 m (E) 0.84 m

54. Which of the following sets of graphs might be the corresponding graphs of Position, Velocity, and Acceleration vs. Time for a moving particle?

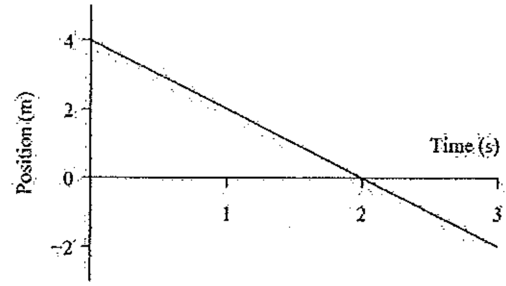



56. A bird is flying in a straight line initially at 10 m/s. It uniformly increases its speed to 15 m/s while covering a distance of 25 m. What is the magnitude of the acceleration of the bird?
(A) 5.0 m/s² (B) 2.5 m/s² (C) 2.0 m/s² (D) 0.5 m/s² (E) 0.2 m/s²

57. A person standing on the edge of a fire escape simultaneously launches two apples, one straight up with a speed of 7 m/s and the other straight down at the same speed. How far apart are the two apples 2 seconds after they were thrown, assuming that neither has hit the ground?
(A) 14 m (B) 20 m (C) 28 m (D) 34 m (E) 56 m

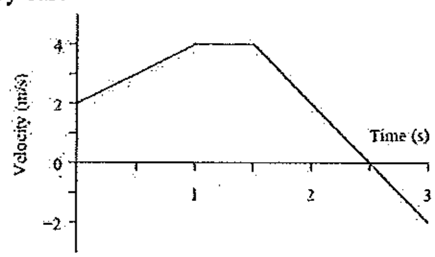
59. A bird flying in a straight line, initially at 10 m/s, uniformly increases its speed to 18 m/s while covering a distance of 40 m. What is the magnitude of the acceleration of the bird?
(A) 0.1 m/s² (B) 0.2 m/s² (C) 2.0 m/s² (D) 2.8 m/s² (E) 5.6 m/s²

61. The position vs. time graph for an object moving in a straight line is shown below. What is the instantaneous velocity at $t = 2$ s?




(A) – 2 m/s (B) ½ m/s (C) 0 m/s (D) 2 m/s (E) 4 m/s

62. Shown below is the velocity vs. time graph for a toy car moving along a straight line. What is the maximum displacement from start for the toy car?




(A) 3 m (B) 5 m (C) 6.5 m (D) 7 m (E) 7.5 m

Name:______________________________ Hour:______

AP Kinematics
Free Response Review Guide
1D Motion

2006B2. A world-class runner can complete a 100 m dash in about 10 s. Past studies have shown that runners in such a race accelerate uniformly for a time $t$ and then run at constant speed for the remainder of the race. A worldclass runner is visiting your physics class. You are to develop a procedure that will allow you to determine the uniform acceleration $a$ and an approximate value of $t$ for the runner in a 100 m dash. By necessity your experiment will be done on a straight track and include your whole class of eleven students.

(a) By checking the line next to each appropriate item in the list below, select the equipment, other than the runner and the track, that your class will need to do the experiment.

____Stopwatches ____Tape measures ____ Rulers ____ Masking tape

____Metersticks ____ Starter's pistol ____ String ____ Chalk

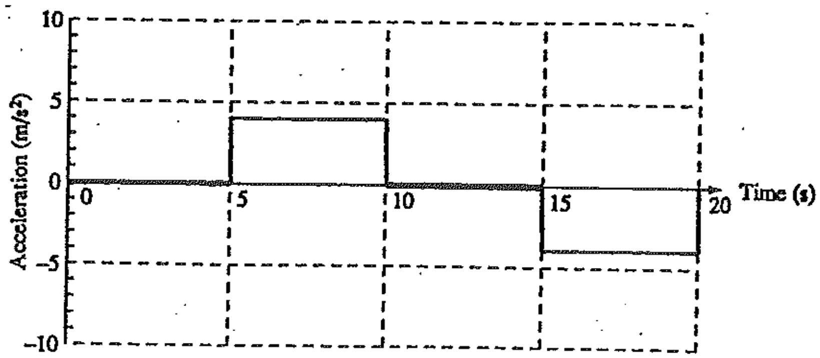
(b) Outline the procedure that you would use to determine $a$ and $t$, including a labeled diagram of the experimental setup. Use symbols to identify carefully what measurements you would make and include in your procedure how you would use each piece of the equipment you checked in part (a).

(c) Outline the process of data analysis, including how you will identify the portion of the race that has uniform acceleration, and how you would calculate the uniform acceleration.

1993B1 (modified)

A student stands in an elevator and records his acceleration as a function of time. The data are shown in the graph above. At time t = 0, the elevator is at displacement x = 0 with velocity v = 0. Assume that the positive directions for displacement, velocity, and acceleration are upward.

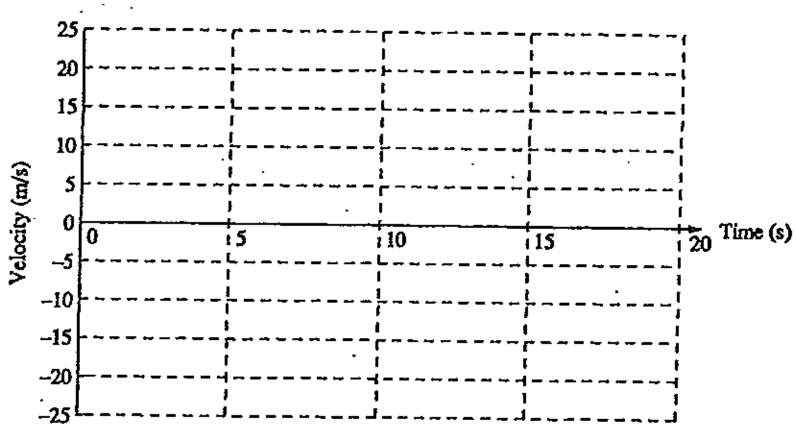
A. Determine the velocity v of the elevator at the end of each 5 second interval.




(i.) Indicate your results by completing the following table.

| Time Interval (s) | 0–5 | 5–10 | 10–15 | 15–20 |
| --- | --- | --- | --- | --- |
| v (m/s) | ____ | ____ | ____ | ____ |

(ii.) Plot the velocity as a function of time on the following graph.

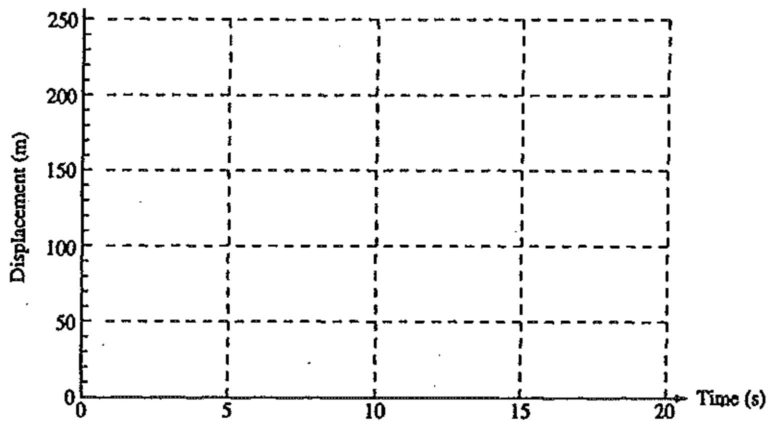


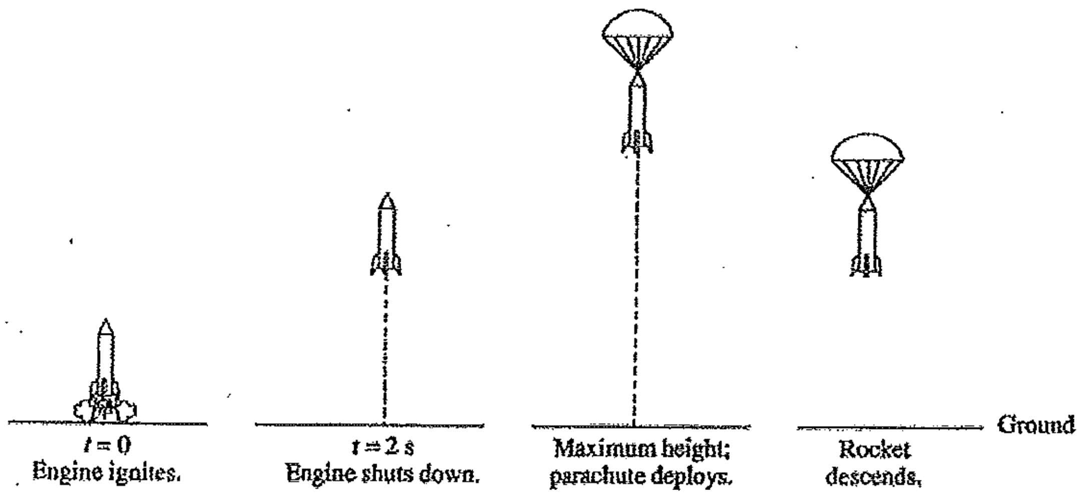
B. Determine the displacement x of the elevator above the starting point at the end of each 5second interval.

(i.) Indicate your results by completing the following table.

| Time Interval (s) | 0–5 | 5–10 | 10–15 | 15–20 |
|---|---|---|---|---|
| x (m) | _____ | _____ | _____ | _____ |

(ii.) Plot the displacement as a function of time on the following graph.





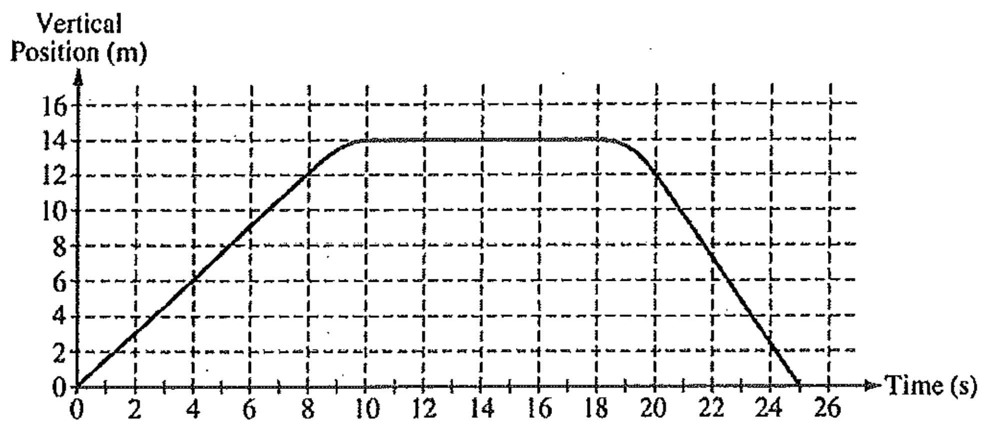

Note: Figures not drawn to scale.

2002B1 (modified) A model rocket is launched vertically with an engine that is ignited at time t = 0, as shown above. The engine provides an upward acceleration of 30 $m/s^2$ for 2.0 s. Upon reaching its maximum height, the rocket deploys a parachute, and then descends vertically to the ground.

a. Determine the speed of the rocket after the 2 s firing of the engine.

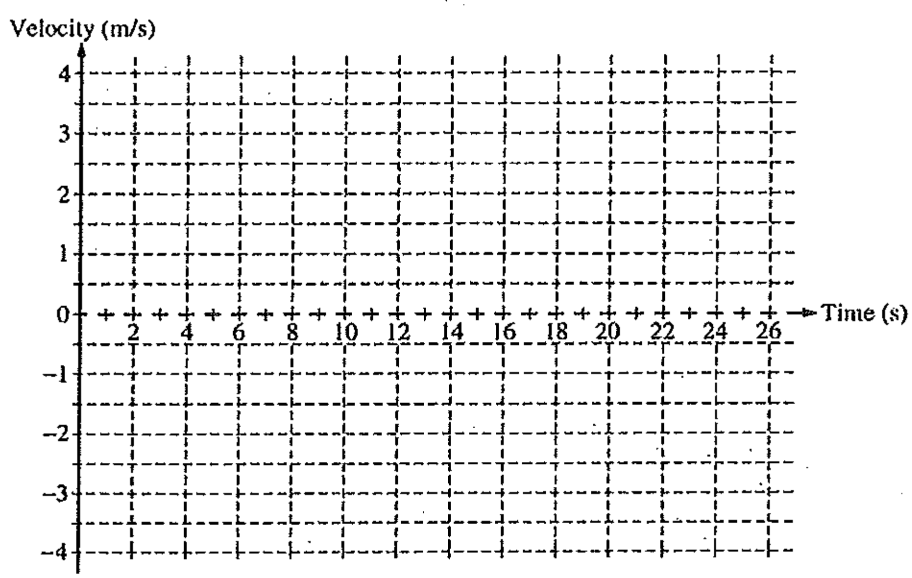
b. What maximum height will the rocket reach?

c. At what time after t = 0 will the maximum height be reached?




2005B1 (modified) The vertical position of an elevator as a function of time is shown above.

a. On the grid below, graph the velocity of the elevator as a function of time.



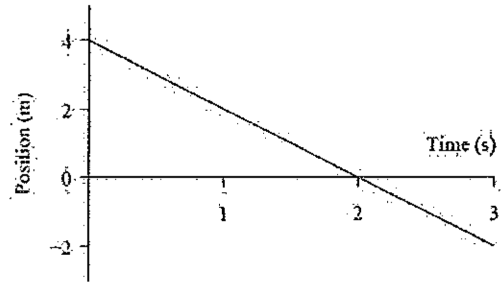

b. i. Calculate the average acceleration for the time period t = 8 s to t = 10 s.

ii. Draw a box below that represents the elevator and draw a vector to represent the direction of this average acceleration.

Kinematics 1d Motion Test
AP Physics/ Rodriguez

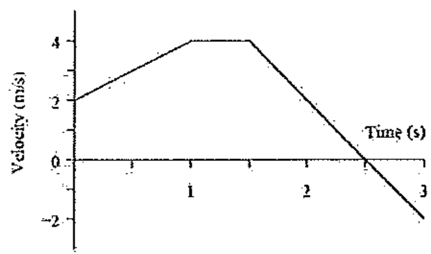
Name:______________________________

1. The position vs. time graph for an object moving in a straight line is shown below. What is the instantaneous velocity at $t = 2$ s?



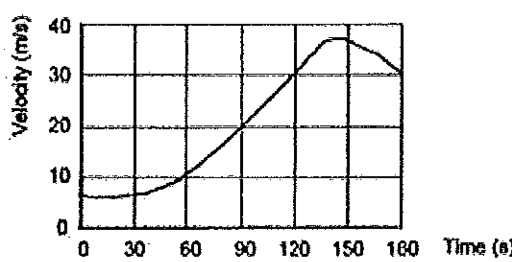

(A) – 2 m/s (B) ½ m/s (C) 0 m/s (D) 2 m/s (E) 4 m/s

2. Shown below is the velocity vs. time graph for a toy car moving along a straight line. What is the maximum displacement from start for the toy car?




(A) 3 m (B) 5 m (C) 6.5 m (D) 7 m (E) 7.5 m

3. The graph shows velocity as a function of time for a car. What was the acceleration at time $t = 90$ seconds?




(A) 0.22 m/s$^2$ (B) 0.33 m/s$^2$ (C) 1.0 m/s$^2$ (D) 9.8 m/s$^2$ (E) 30 m/s$^2$

4. An object is released from rest and falls a distance $h$ during the first second of time. How far will it fall during the next second of time?

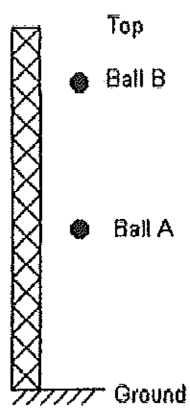
(A) $h$ (B) $2h$ (C) $3h$ (D) $4h$ (E) $h^2$

5. A stone is thrown straight downward with a speed of 20 m/s from the top of a tall building. If the stone strikes the ground 3.0 s later, about how tall is the building? Assume air resistance is negligible.
(A) 45 m (B) 60 m (C) 90 m (D) 105 m (E) 120 m

6. A coyote can run at a speed of 20 m/s while a prairie dog can manage only 5.5 m/s. If a prairie dog is 45 m in front of a coyote, what is the maximum time it has to reach its hole without being caught?
(A) 2.3 s (B) 3.1 s (C) 5.4 s (D) 5.9 s (E) 8.2 s

7. A model rocket accelerates from rest upwards at 50 m/s$^2$ for 2.0 s before its engine burns out. The rocket then coasts upward. What is the maximum height that the rocket reaches? You may assume air resistance is negligible.
(A) 100 m (B) 510 m (C) 610 m (D) 1020 m (E) 1220 m

8. Two identical bowling balls A and B are each dropped from rest from the top of a tall tower as shown in the diagram below. Ball A is dropped 1.0 s before ball B is dropped but both balls fall for some time before ball A strikes the ground. Air resistance can be considered negligible during the fall. After ball B is dropped but before ball A strikes the ground, which of the following is true?

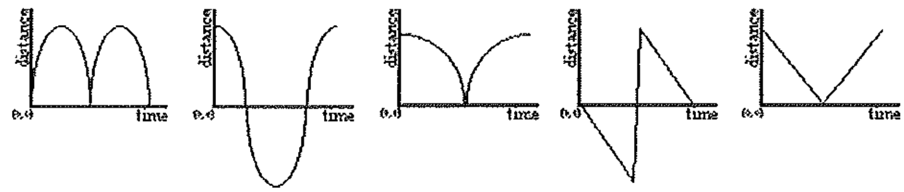



(A) The distance between the two balls decreases.
(B) The velocity of ball A increases with respect to ball (B)
(C) The velocity of ball A decreases with respect to ball (B)
(D) The distance between the two balls remains constant.
(E) The distance between the two balls increases.

Questions 9-10

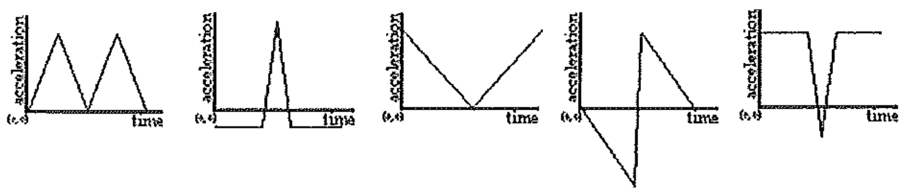
The following TWO questions refer to the following information. An ideal elastic rubber ball (it doesn't lose any energy to deformation, sound, or heat during the collision) is dropped from a height of about 2 meters, hits the floor and rebounds to its original height.

9. Which of the following graphs would best represent the distance above the floor versus time for the above bouncing ball?




A) B) C) D) E)

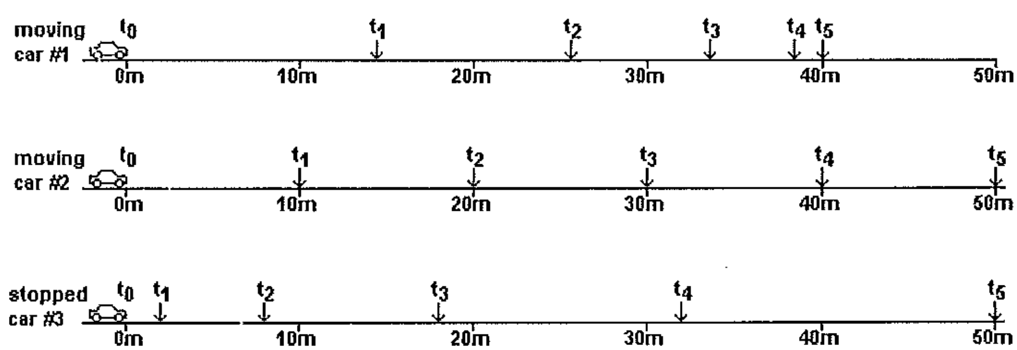
10. Which of the following graphs would best represent acceleration versus time for the bouncing ball?




A) B) C) D) E)

Questions 11 through 14 refer to the following scenario:

At $t_0$, two cars moving along a highway are side-by-side as they pass a third car stopped on the side of the road. At this moment the driver of the first car steps on the brakes while the driver of the stopped car begins to accelerate. The diagrams below show the positions of each car for the next 5 seconds.




11. During which time interval would cars #2 and #3 be moving at the same average speed?
(A) $t_0$ to $t_1$ (B) $t_1$ to $t_2$ (C) $t_2$ to $t_3$ (D) $t_3$ to $t_4$ (E) $t_4$ to $t_5$

12. About what position after $t_0$ would car #1 and car #2 have been side by side?
(A) 0 m (B) 15 m (C) 26 m (D) 37 m (E) 39 m

13. Which of the three cars had the greatest average speed during these 5 seconds?
(A) car #1 (B) car #2 and car #3 had the same average speed (C) car #2
(D) all three cars had the same average speed (E) car #3

14. If car #3 continues to constantly accelerate at the same rate what will be its position at the end of 6 seconds?
(A) 22 m (B) 68 m (C) 72 m (D) 78 m (E) 94 m

## Free Response

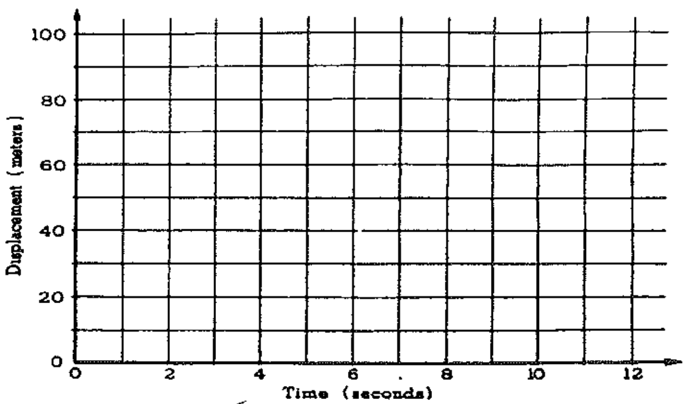
1. The first meters of a 100meter dash are covered in 2 seconds by a sprinter who starts from rest and accelerates with a constant acceleration. The remaining 90 meters are run with the same velocity the sprinter had after 2 seconds. Remember to show all work.

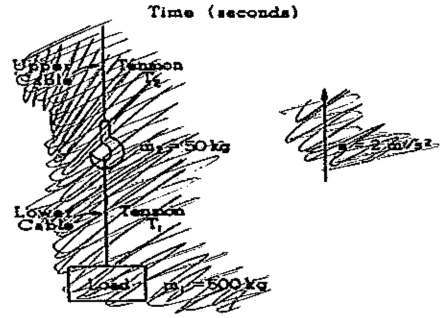
a. Determine the sprinter's constant acceleration during the first 2 seconds.

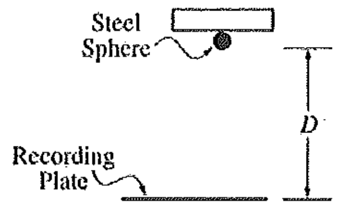
b. Determine the sprinters velocity after 2 seconds have elapsed.

c. Determine the total time needed to run the full 100 meters.

d. On the axes provided below, draw the displacement vs time curve for the sprinter.

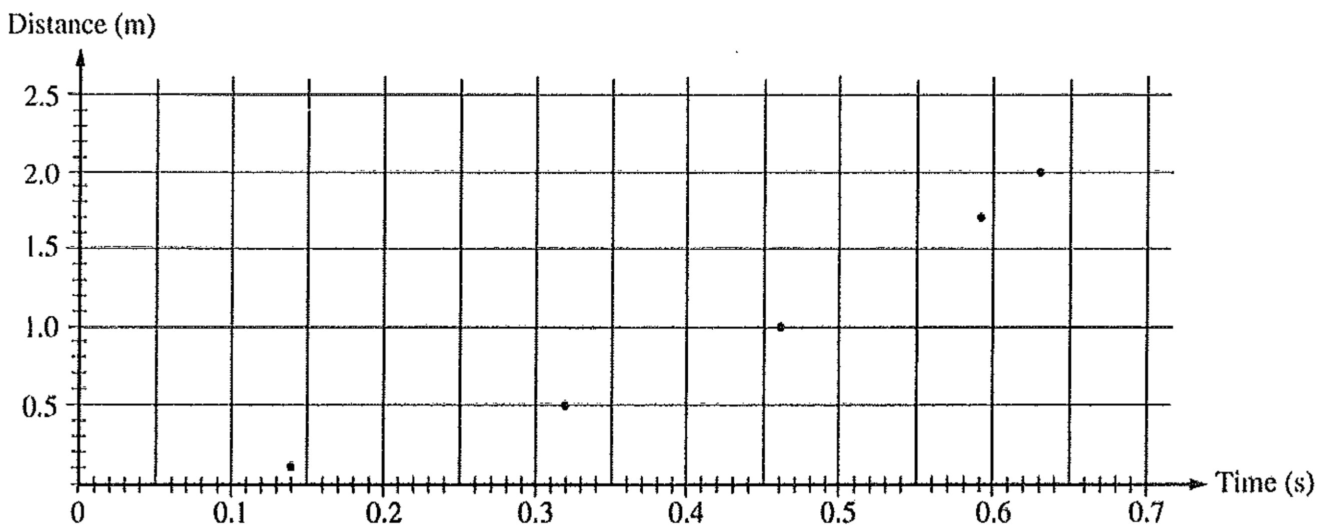





2. A student wishing to determine experimentally the acceleration *g* due to gravity has an apparatus that holds a small steel sphere above a recording plate, as shown above. When the sphere is released, a timer automatically begins recording the time of fall. The timer automatically stops when the sphere strikes the recording plate.
The student measures the time of fall for different values of the distance *D* shown above and records the data in the table below. These data points are also plotted on the graph.

| Distance of Fall (m) | 0.10 | 0.50 | 1.00 | 1.70 | 2.00 |
|---|---|---|---|---|---|
| Time of Fall (s) | 0.14 | 0.32 | 0.46 | 0.59 | 0.63 |

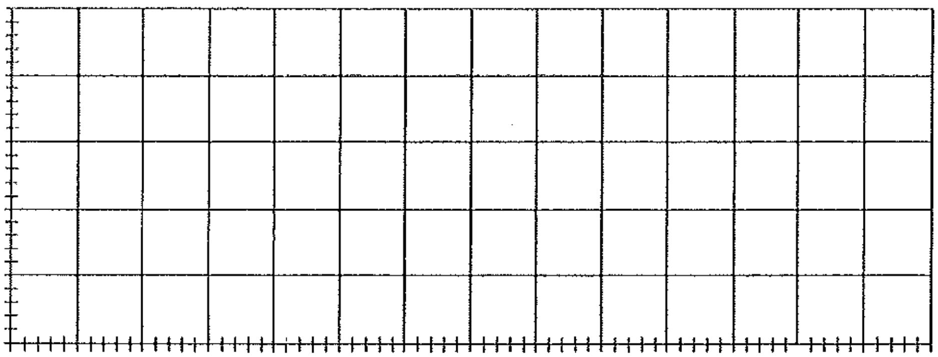



a) On the grid above, sketch the smooth curve that best represents the student's data

The student can use these data for distance D and time t to produce a second graph from which the acceleration g due to gravity can be determined.

(b) If only the variables D and t are used, what quantities should the student graph in order to produce a linear relationship between the two quantities?

(c) On the grid below, plot the data points for the quantities you have identified in part (b), and sketch the best straight-line fit to the points. Label your axes and show the scale that you have chosen for the graph.



(d) Using the slope of your graph in part (c), calculate the acceleration g due to gravity in this experiment.

(e) State one way in which the student could improve the accuracy of the results if the experiment were to be performed again. Explain why this would improve the accuracy.

Name:________________________________

AP Physics
2d Kinematics Review Guide
Rodriguez

1. A man and his wife are holding hands in the park when they besieged by a manic ferret. The ferret crawls straight up the man's shoulder height of 1.5m. It then runs down his arm (at a 60 degree angle below the horizontal). After traveling 0.8m down the man's arm, it scampers 0.7m up the woman at an angle of 45 degrees. The entire horrifying ordeal lasts 2 seconds.

A) How much distance did the ferret cover?

B) What is the ferret's final displacement (don't forget direction)?

C) What is the ferret's average velocity?

2. An otter can swim at 6m/s. If an otter aims itself directly across a 78m river, it ends up being pushed 200m downstream.

A) How fast is the current in the river?

B) What is the otter's net velocity? (don't forget direction too!)

3. Protesters are yelling at a monkey for wearing fur. The monkey is 50m from the protesters on a branch 2m off the ground. A protester shoots a 250 m/s paintball horizontally from a height of 2m.

(a) In order to avoid being hit, should the monkey drop off the branch or stay on it? Explain why.

(b) What will the height of the paintball be when it is 50m in front of the gun?

4. Miguel Cabrera hits a baseball at an angle of 30 degrees with a velocity of 44m/s. The outfield fence is 130m away and is 3m tall. If Cabrera's bat connects with the ball 1.5m above the ground...

(a) How long does it take the ball to reach the plane of the fence?

(b) How high is the ball when it reaches the fence?

(c) How far from where it is hit does it land?

(d) How long is it in the air?

5. You are driving 30 mph to the east when a car goes by you in the opposite direction at 40mph.

(a) What is your speed relative to your car?

(b) What is your speed relative to the other car?

(c) What is your speed relative to the ground?

6. A ball falling at 25 m/s straight down is blown by a 7 m/s wind at an angle of 30 degrees down from right. What angle will the ball's new velocity make with the vertical? How far off course will the ball be blown in 15 seconds

7. For the following problem, use only the given variables and fundamental constants in your answer. A fig is thrown straight up from the back of a camel at a height of H meters. It is thrown upwards with a velocity of $v_o$ m/s.

(a) What is the maximum height attained by the fig?

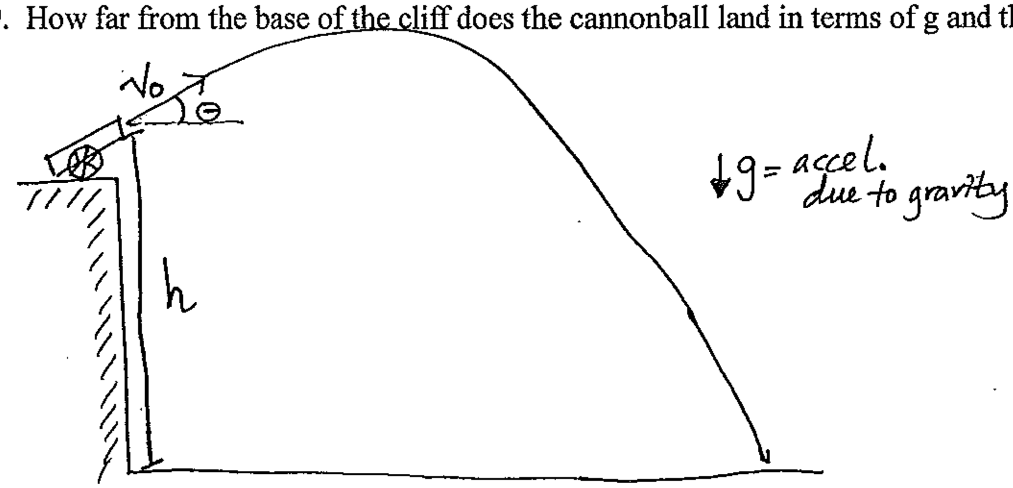
(b) What is the velocity of the fig when it passes the height it is thrown from on its way down.

(c) How long is it in the air?

(d) What is its velocity when it reaches the ground?

8. A golf ball is launched from a 14m tall terrace at 25 m/s at an angle of 35 degrees up from the horizontal. How far away from the terrace does it land?

9. How far from the base of the cliff does the cannonball land in terms of g and the variables given?



Name:________________________

AP Physics Test
Rodriguez

1. A man throws a bouncy ball down at 25 m/s, it bounces off the ground 5m below at the same speed that it hits the ground. After how many seconds will he catch the ball?

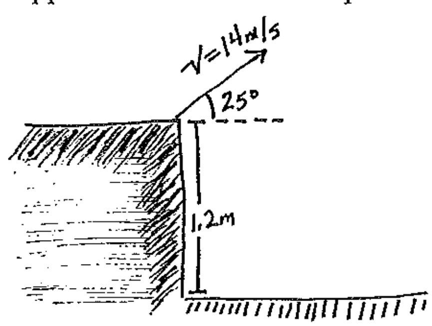
2. You are driving 50 mph to the west when a car goes by you in the opposite direction at 35 mph.

(a.) What is your speed relative to your car?

(b.) What is your speed relative to the other car?

(c.) What is the ground's speed relative to you?

(d.) What is your speed relative to the ground?




3. Given a projectile launched from an initial height of 1.2m above the horizontal at 14 m/s at an angle of 25 degrees above the horizontal. See drawing above

(a.) Find max height

(b.) Time in the air

(c) What is the range?

4. A dog doggy paddles across a river which is 50m wide. The dog can swim at 1m/s in still water. If the dog ends up 12m downstream when it reaches the other side,

(a) What is the current in the river?

(b) What direction relative to the starting shore did the puppy swim along?

(c) What was the speed of the dog's swim?

5. A student drops some flubber from the roof of the high school (y meters above the ground). When the flubber bounces, it has the same speed as it did right before the rebound (it's perfectly elastic). "g" is the acceleration due to gravity. In terms of g, and the variables given, find:

(a) The velocity of the ball right before it hits the ground.

(b) The velocity of the ball right after hitting the ground.

(c) The time it takes for the ball to hit the ground.

(d) How high the ball will bounce.

(e) The speed of the ball when it reaches a height of Y after bouncing.

Extra Credit:

A Springloaded gun can fire a projectile to a height $h$ if it is fired Straight up. If the same gun is pointed at an angle of 45° from the vertical, what maximum height can now be reached by the projectile?

(A) $\frac{h}{4}$ (B) $\frac{h}{2\sqrt{2}}$ (C) $\frac{h}{2}$ (D) $\frac{h}{\sqrt{2}}$ (E) $h$

# ADVANCED PLACEMENT PHYSICS 1 EQUATIONS, EFFECTIVE 2015

## MECHANICS

$v_x = v_{x0} + a_x t$

$x = x_0 + v_{x0} t + \frac{1}{2} a_x t^2$

$v_x^2 = v_{x0}^2 + 2a_x (x - x_0)$

$\vec{a} = \frac{\sum \vec{F}}{m} = \frac{\vec{F}_{net}}{m}$

$|\vec{F}_f| \le \mu |\vec{F}_n|$

$a_c = \frac{v^2}{r}$

$\vec{p} = m\vec{v}$

$\Delta\vec{p} = \vec{F}\,\Delta t$

$K = \frac{1}{2} m v^2$

$\Delta E = W = F_{\parallel} d = F d \cos\theta$

$P = \frac{\Delta E}{\Delta t}$

$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

$\omega = \omega_0 + \alpha t$

$x = A\cos(2\pi f t)$

$\vec{\alpha} = \frac{\sum \vec{\tau}}{I} = \frac{\vec{\tau}_{net}}{I}$

$\tau = r_{\perp} F = rF\sin\theta$

$L = I\omega$

$\Delta L = \tau\,\Delta t$

$K = \frac{1}{2} I \omega^2$

$|\vec{F}_s| = k|\vec{x}|$

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

$\rho = \frac{m}{V}$

$a$ = acceleration
$A$ = amplitude
$d$ = distance
$E$ = energy
$f$ = frequency
$F$ = force
$I$ = rotational inertia
$K$ = kinetic energy
$k$ = spring constant
$L$ = angular momentum
$\ell$ = length
$m$ = mass
$P$ = power
$p$ = momentum
$r$ = radius or separation
$T$ = period
$t$ = time
$U$ = potential energy
$V$ = volume
$v$ = speed
$W$ = work done on a system
$x$ = position
$y$ = height
$\alpha$ = angular acceleration
$\mu$ = coefficient of friction
$\theta$ = angle
$\rho$ = density
$\tau$ = torque
$\omega$ = angular speed

$\Delta U_g = mg\,\Delta y$

$T = \frac{2\pi}{\omega} = \frac{1}{f}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_p = 2\pi\sqrt{\frac{\ell}{g}}$

$|\vec{F}_g| = G\frac{m_1 m_2}{r^2}$

$\vec{g} = \frac{\vec{F}_g}{m}$

$U_G = -\frac{G m_1 m_2}{r}$

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## ELECTRICITY

$|\vec{F}_E| = k\left|\frac{q_1 q_2}{r^2}\right|$

$I = \frac{\Delta q}{\Delta t}$

$R = \frac{\rho \ell}{A}$

$I = \frac{\Delta V}{R}$

$P = I\,\Delta V$

$R_s = \sum_i R_i$

$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$

$A$ = area
$F$ = force
$I$ = current
$\ell$ = length
$P$ = power
$q$ = charge
$R$ = resistance
$r$ = separation
$t$ = time
$V$ = electric potential
$\rho$ = resistivity

## WAVES

$\lambda = \frac{v}{f}$

$f$ = frequency
$v$ = speed
$\lambda$ = wavelength

## GEOMETRY AND TRIGONOMETRY

Rectangle
$A = bh$

Triangle
$A = \frac{1}{2} bh$

Circle
$A = \pi r^2$
$C = 2\pi r$

Rectangular solid
$V = \ell w h$

Cylinder
$V = \pi r^2 \ell$
$S = 2\pi r \ell + 2\pi r^2$

Sphere
$V = \frac{4}{3}\pi r^3$
$S = 4\pi r^2$

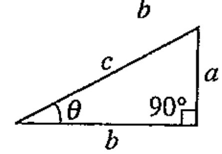
$A$ = area
$C$ = circumference
$V$ = volume
$S$ = surface area
$b$ = base
$h$ = height
$\ell$ = length
$w$ = width
$r$ = radius

Right triangle
$c^2 = a^2 + b^2$

$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$



# ADVANCED PLACEMENT PHYSICS 1 EQUATIONS, EFFECTIVE 2015

| CONSTANTS AND CONVERSION FACTORS | | | |
|---|---|---|---|
| Proton mass, | $m_p = 1.67 \times 10^{-27}$ kg | Electron charge magnitude, | $e = 1.60 \times 10^{-19}$ C |
| Neutron mass, | $m_n = 1.67 \times 10^{-27}$ kg | Coulomb's law constant, | $k = 1/4\pi\varepsilon_0 = 9.0 \times 10^9 \ \text{N}\cdot\text{m}^2/\text{C}^2$ |
| Electron mass, | $m_e = 9.11 \times 10^{-31}$ kg | Universal gravitational constant, | $G = 6.67 \times 10^{-11} \ \text{m}^3/\text{kg}\cdot\text{s}^2$ |
| Speed of light, | $c = 3.00 \times 10^8$ m/s | Acceleration due to gravity at Earth's surface, | $g = 9.8 \ \text{m/s}^2$ |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| UNIT SYMBOLS | meter, | m | kelvin, | K | watt, | W | degree Celsius, | °C |
| | kilogram, | kg | hertz, | Hz | coulomb, | C | | |
| | second, | s | newton, | N | volt, | V | | |
| | ampere, | A | joule, | J | ohm, | Ω | | |

| PREFIXES | | |
|---|---|---|
| Factor | Prefix | Symbol |
| $10^{12}$ | tera | T |
| $10^9$ | giga | G |
| $10^6$ | mega | M |
| $10^3$ | kilo | k |
| $10^{-2}$ | centi | c |
| $10^{-3}$ | milli | m |
| $10^{-6}$ | micro | μ |
| $10^{-9}$ | nano | n |
| $10^{-12}$ | pico | p |

VALUES OF TRIGONOMETRIC FUNCTIONS FOR COMMON ANGLES

| $\theta$ | 0° | 30° | 37° | 45° | 53° | 60° | 90° |
|---|---|---|---|---|---|---|---|
| $\sin\theta$ | 0 | 1/2 | 3/5 | $\sqrt{2}/2$ | 4/5 | $\sqrt{3}/2$ | 1 |
| $\cos\theta$ | 1 | $\sqrt{3}/2$ | 4/5 | $\sqrt{2}/2$ | 3/5 | 1/2 | 0 |
| $\tan\theta$ | 0 | $\sqrt{3}/3$ | 3/4 | 1 | 4/3 | $\sqrt{3}$ | ∞ |

The following conventions are used in this exam.

I. The frame of reference of any problem is assumed to be inertial unless otherwise stated.
II. Assume air resistance is negligible unless otherwise stated.
III. In all situations, positive work is defined as work done on a system.
IV. The direction of current is conventional current: the direction in which positive charge would drift.
V. Assume all batteries and meters are ideal unless otherwise stated.