I'm not robot
reCAPTCHA
Continue

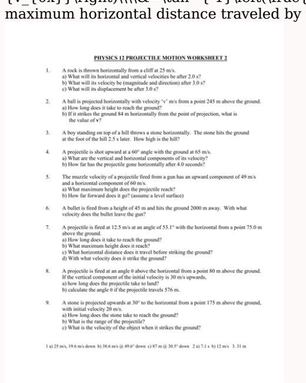
Physics projectile motion worksheet answers

Physics 12 projectile motion worksheet 2 answers. Physics 30 worksheet answers. Physics worksheet answers. Physics definition of projectile. Physics work worksheet answers. Projectile motion worksheet answers the physics classroom.

EN FR DE ES IT HR SV SR SL NL We and our partners use cookies to Store and/or access information on a device. We and our partners use data for Personalised ads and content, ad and content measurement, audience insights and product development. An example of data being processed may be a unique identifier stored in a cookie. Some of our partners may process your data as a part of their legitimate business interest without asking for consent. To view the purposes they believe they have legitimate interest for, or to object to this data processing use the vendor list link below. The consent submitted will only be used for data processing originating from this website. If you would like to change your settings or withdraw consent at any time, the link to do so is in our privacy policy accessible from our home page.. Continue with Recommended Cookies Loading... Projectile motion problems with descriptive solutions are provided for high school and college students. Every single question is designed to be a complete guide on this topic without referring to your textbook. There is also a pdf helpful for worksheets with answers. Overview of projectile motion: Any motion having the following conditions is called a projectile motion. (i) Follows a parabolic path (trajectory) (ii) Moves under the influence of gravity. The projectile motion formulas applied to solve two-dimensional projectile motion problems are as follows \begin{gather*} x=(v_0\cos\theta)t+x_0\\\\y=-\frac 12 gt^2+(v_0\sin\theta)t+y_0\\\\ v_y=v_0\sin\theta-gt\\\\v_y^2-(v_0\sin\theta)^2=-2g(y-y_0)\end{gather*} In the next section, we want to know how to solve projectile motion problems in the AP physics exams using these kinematic equations. Projectile motion problems and answers Problem (1): A person kicks a ball with an initial velocity of $15\,{\rm m/s}$ at an angle of 37° above the horizontal (neglecting the air resistance). Find (a) the total time the ball is in the air. (b) the horizontal distance traveled by the ball Solution: To solve any projectile motion problems, first of all, adopt a coordinate system and draw the projectile path, putting the initial and final positions, and velocities on it. By doing so, you will be able to solve the relevant projectile equations easily. Hence, we choose the origin of the coordinate system to be at the throwing point, $x_0=0, y_0=0$. (a) Here, the time between throwing and striking the ground is wanted. In effect, the projectiles have two independent motions: one in the horizontal direction with uniform motion at a constant velocity, i.e., $a_x=0$, and the other in the vertical direction under the effect of gravity, with $a_y=-g$. The kinematic equations that describe the horizontal and vertical distances are as follows \begin{gather*} x=x_0+(\underbrace{v_0\cos \theta}_{v_{0x}})t \\ y=-\frac 12 gt^2+(\underbrace{v_0\sin \theta}_{v_{0y}})t+y_0\end{gather*} By substituting the coordinates of the initial and final points into the vertical equation, we can find the total time the ball is in the air. Setting $y=0$ in the second equation (because the projectile lands at the same level as the throwing point.), we have \begin{align*} y&=-\frac 12 gt^2+(v_0\sin \theta)t+y_0\\\\ 0&=-\frac 12 (9.8)t^2+(15)\sin 37^\circ\,t+0 \end{align*} By rearranging the above expression, we can get two solutions for t: \begin{gather*} t_1=0 \\\\ t_2=\frac{2\times 15\sin37^\circ}{9.8}=1.84\,{\rm s}\end{gather*} The first time is for the starting moment, and the second is the total time the ball was in the air. (b) As mentioned above, the projectile motion is made up of two independent motions with different positions, velocities, and accelerations, and two distinct kinematic equations describe those motions. Between any two desired points in the projectile path, the time needed to move horizontally to reach a specific point is the same time needed to fall vertically to that point. This is an important observation in solving projectile motion problems. Therefore, time is the only common quantity in the horizontal and vertical motions of a projectile. In this problem, the time obtained in part (a) can be substituted in the horizontal kinematic equation, to find the distance traveled as below \begin{align*} x&=x_0+(v_0\cos \theta)t \\ &=0+(15)\cos 37^\circ\,(1.84) \\ &=22.08\quad {\rm m}\end{align*} Be sure to check the following questions. If you are getting ready for the AP Physics exam, probably these problems on the kinematics equation (or these AP Physics Kinematics Problems) are also useful to you. Problem (2): A ball is thrown into the air at an angle of 60° above the horizontal with an initial velocity of $40\,{\rm m/s}$ from a 50-m-high building. Find (a) The time to reach the top of its path. (b) The maximum height the ball reached from the base of the building. Solution: In the previous question, we found that the projectile is a motion composed of two vertical and horizontal motions. We learned about how to find distances in both directions using relevant kinematic equations. There is also another set of kinematic equations that discuss the velocities in vertical and horizontal directions as follows \begin{gather*} v_x=v_{0x}=v_0\cos\theta \\ v_y=v_{0y}-gt=v_0\sin\theta-gt\end{gather*} As you can see, the horizontal component of the velocity, v_x, is constant throughout the motion, but the vertical component varies with time. As an important note, keep in mind that in the problems about projectile motions, at the highest point of the trajectory, the vertical component of the velocity is always zero, i.e., $v_y=0$. To solve the first part of the problem, specify two points as the initial and final points, then solve the relevant kinematic equations between those points. Here, setting $v_y=0$ in the second equation and solving for the unknown time t, we have \begin{align*} v_y&=v_{0y}-gt \\\\ &=v_0\sin\theta-gt \\\\ 0&=(40)(\sin 60^\circ)-(9.8)(t) \\\\ \Rightarrow t&=\boxed{3.53\, {\rm s}}\end{align*} Thus, the time taken to reach the maximum height of the trajectory (path) is 3.53 seconds from the moment of the launch. We call this maximum time t_{max}. (b) Let the origin be at the throwing point so $x_0=y_0=0$ in the kinematic equations. In this part, the vertical distance traveled to the maximum point is requested. By substituting t_{max} into the vertical distance projectile equation, we can find the maximum height as below \begin{align*} y-y_0&=-\frac 12 gt^2 +(v_0 \sin \theta)t\\ \\ y_{max}&=-\frac 12 (9.8)(3.53)^2+(40 \sin 60^\circ)(3.53)\\\\ &=61.22\quad {\rm m}\end{align*} Therefore, the maximum height the ball is reached from the base of the building is \[H=50+y_{max}=111.22\quad {\rm m}\] For further reading about uniform motion along the horizontal direction, see speed, velocity, and acceleration problems. Problem (3): A person standing on the edge of a $50-\rm m$-high cliff throws a stone horizontally with a speed of $18\,\rm m/s$. (a) What is the initial position of the stone? (b) What are the components of the initial velocity? (c) What are the x- and y-components of the velocity of the stone at any arbitrary time t? (d) How long will it take the stone to strike the bottom of the cliff? (e) With what angle and speed does the stone strike the ground below the cliff?

Solution: As mentioned repeatedly, as a first step to solving a projectile motion problem, choose a relevant coordinate system. (a) Usually, we place the origin of the coordinate system at the point where the projectile is thrown. In this case, the coordinate of the initial position is $x_0=0\, , \, y_0=0$. If we had chosen the coordinate at the base of the cliff and placed the origin at that point, the position of the initial point would have been $x_0=0\, , \, y_0=50\,\rm m$. (b) The stone is thrown horizontally, $\theta=0$, so there is no vertical velocity component. Consequently, their initial speed components are $v_{0x}=18\,\rm m/s$ and $v_{0y}=0$. (c) Recall that the components of the velocity of a projectile vary with time according to the following formula. Substitute the given values into it, gives \begin{align*} v_x&=v_{0x}=18\,\rm m/s \\\\ v_y&=v_{0y}-gt\\&=-9.8t \end{align*} (d) If we take the top of the cliff as the origin of our coordinate system, $x_0=y_0=0$, the stone strikes the ground $50\,\rm m$ below our chosen origin, so the coordinates of that point would be $x_0=?\, ,\, y=-50\,\rm m$. Use the vertical displacement kinematic equation below, substitute the numerical values into that, and solve for time t get \begin{gather*} y-y_0=-\frac 12 gt^2+v_{0y}t \\\\ -50-0=-\frac 12 (9.8)t^2-0 \\\\ \Rightarrow \quad \boxed{t=3.2\,\rm s} \end{gather*} (e) First, find the velocity components just before the stone hits the ground. We know that it takes about $3.2\,\rm s$ for the stone to reach the bottom of the cliff. Thus, put this time value into the formulas of velocity components at any time t. \begin{align*} v_x&=v_{0x}=18\,\rm m/s \\\\ v_y&=v_{0y}-gt\\&=-9.8\times 3.2 \\&=-31.36\,\rm m/s \end{align*} Notice that the negative sign here indicates that the vertical velocity component just before hits the ground points downward, as expected. Recall from the section of vector practice problems that have the components of a vector, its magnitude is simply found using the Pythagorean theorem as follows \begin{align*} v&=\sqrt{v_x^2+v_y^2} \\\\ &=\sqrt{18^2+(-31.36)^2} \\ &=\boxed{36.15\,\rm m/s} \end{align*} The angle of impact with the ground, having the velocity components, is also obtained as below \begin{align*} \tan\theta&=\frac{v_y}{v_x} \\\\ &=\frac{-31.36}{18} \\\\ &=-1.74 \end{align*} Taking the inverse tangent of both sides, gives \[\theta=\tan^{-1}(-1.74)=\boxed{-60.1^\circ} \] Therefore, the stone hit the ground at an angle of about 60° with a speed of $36.15\,\rm m/s$. The negative indicates that the angle is below horizontal, which is to be expected. Download Now and get 50% off!: 550 solved high school physics midterm and final exams ($4). Problem (4): A box slides off a frictionless tabletop with a constant speed of $1.1\,\rm m/s$, and $0.35\,\rm s$ later strikes the floor. (a) How high is the tabletop from the floor? (b) What is the horizontal distance to that point where the book strikes the floor? (c) How fast and at what angle does the book strike the floor? Solution: The total time in the air, $t=0.35\,\rm s$, and the initial speed with which the book leaves the table horizontally, i.e., $v_{0x}=1.1\,\rm m/s$, and $v_{0y}=0$. Contrary to the earlier question, in this case, for practice, we place the origin at the bottom of the tabletop. Thus, the coordinates of the initial position would be $x_0=0\, ,\, y_0=h=?$ and the coordinate of the landing point would be $x=? \, , \, y=0$. (a) If we substitute the given values into the vertical displacement kinematic equation, we will have \begin{gather*} y-y_0=-\frac 12 gt^2+v_{0y}t \\\\ 0-h=-\frac 12 (9.8)(1.1)^2+0 \\\\ \Rightarrow \quad \boxed{h=5.93\,\rm m} \end{gather*} Thus, the table is 3-m-high. (b) Recall that projectile motion consists of two uniform horizontal and vertical accelerated motions. The time taken by the projectile in the vertical direction is equal to the horizontal time to the landing point. Between the start and final points in the horizontal direction of the projectile path, we can write $\Delta x=v_{0x}t$. Substituting the given values into is get \begin{gather*} x-0=1.1\times (0.35) \\ \Rightarrow \quad \boxed{x=0.385\,\rm m} \end{gather*} where $\Delta x=x-x_0$. Therefore, the book strikes the floor about $39\,\rm cm$ ahead of the base of the table. (c) This part is straightforward.

Substitute the given numerical values into the velocity vector components formulas as below to find the velocity components just before the book strikes the floor. \begin{align*} v_x&=v_{0x}=1.1\,\rm m/s \\\\ v_y&=v_{0y}-gt \\\\ &=0-(9.8)(0.35) \\&=-3.43\,\rm m/s \end{align*} The square root of the sum of the velocity components squared gives the velocity of the book at the instant of hitting \begin{align*} v&=\sqrt{v_x^2+v_y^2} \\\\ &=\sqrt{1.1^2+(-3.43)^2} \\\\ &=\boxed{3.6\,\rm m/s} \end{align*} and angle of impact with the ground is found as below \begin{align*} \theta&=\tan^{-1}\left(\frac{v_y}{v_x}\right) \\\\ &=\tan^{-1}\left(\frac{-3.43}{1.1}\right) \\\\ &=\tan^{-1}(-3.11) \\\\&=\boxed{-72.17^\circ} \end{align*} Overall, the book hit the ground at an angle of about 72° with a speed of nearly $3.6\,\rm m/s$. Problem (5): A cannonball is fired from a cliff with a speed of 800 m/s at an angle of 30° below the horizontal. How long will it take to reach 150 m below the firing point? Solution: First, choose the origin to be at the firing point, so $x_0=y_0=0$. Now, list the known values below (i) Projectile's initial velocity = $800\,{\rm m/s}$ (ii) Angle of projectile: -30°, the negative sign is because the throw is below horizontal. (iii) y-coordinate of the final point, 150 m below the origin, $y=-150\,{\rm m}$. In this problem, the time it takes for the cannonball to reach 100 m below the starting point is required. Since the displacement to that point is known, we apply the vertical displacement projectile formula to find the needed time as below \begin{align*} y-y_0&=-\frac 12 gt^2+(v_0\sin\theta)t\\\-150&=-\frac 12 (9.8)t^2+(800)\sin(-30^\circ)t\\\\ \Rightarrow & \ 4.9t^2+400t-150=0\end{align*} The above quadratic equation has two solutions, $t_1=0.37\,{\rm s}$ and $t_2=-82\,{\rm s}$. It is obvious that the second time is not acceptable. Therefore, the cannonball takes 0.37 seconds to reach 150 meters below the firing point. Problem (6): Someone throws a stone into the air from ground level. The horizontal component of velocity is 25 m/s and it takes 3 s for the stone to come back to the same height as before. Find (a) The range of the stone. (b) The initial vertical component of velocity (c) The angle of projection. Solution: The known value is (i) The initial horizontal component of velocity, $v_{0x}=25\,{\rm m/s}$. (ii) The time between the initial and final points, which are at the same level, $t=3\,{\rm s}$. (a) The range of projectile motion is defined as the horizontal distance between the launch point and impact at the same elevation. Because the horizontal motion in projectiles is a motion with constant velocity, the distance traveled in this direction is obtained as $x=v_{0x}t$, where v_{0x} is the initial component of the velocity. If you put the total time the projectile is in the air into this formula, you get the range of the projectile. In this problem, the stone is thrown from the ground level and after 3 s reaches the same height. Thus, this is the total time of the projectile. Hence, the range of the stone is found as below \begin{align*} x&=v_{0x}t\\&=(25)(3)\\&=75\,{\rm m}\end{align*} (b) The initial vertical component of the projectile's velocity appears in two equations, $v_y=v_{0y}-gt$ and $y-y_0=-\frac 12 gt^2+v_{0y}t$. Using the second formula is more straightforward because the stone reaches the same height, so its vertical displacement between the initial and final points is zero, i.e., $y-y_0=0$. Setting this into the vertical distance projectile equation, we get \begin{align*} y-y_0&=-\frac 12 gt^2+v_{0y}t\\\\ 0&=-\frac 12 (9.8)(3)^2+v_{0y}(3) \\\\ \Rightarrow v_{0y}&=14.7\quad{\rm m/s}\end{align*} To use the first formula, we need some extra facts about projectile motion in the absence of air resistance, as below (i) The vertical velocity is zero at the highest point of the path of the projectile, i.e., $v_y=0$. (ii) If the projectile lands at the same elevation from which it was launched, then the time it takes to reach the highest point of the trajectory is half the total time between the initial and final points. The second note, in the absence of air resistance, is only valid. In this problem, the total flight time is 3 s because air resistance is negligible, so 1.5 seconds are needed for the stone to reach the maximum height of its path. Therefore, using the second equation, we can find v_{0y} as below \begin{align*} v_y&=v_{0y}-gt\\0&=v_{0y}-(9.8)(1.5) \\\Rightarrow v_{0y}&=14.7\quad {\rm m/s}\end{align*} (c) The projection angle is the angle at which the projectile is thrown into the air and performs a two-dimensional motion. Once the components of the initial velocity are available, using trigonometry, we can find the angle of projection as below \begin{align*} \theta&=\tan^{-1}\left(\frac{v_{0y}}{v_{0x}}\right)\\\\&=\tan^{-1}\left(\frac{14.7}{25}\right)\\\\&=+30.45^\circ\end{align*} Therefore, the stone is thrown into the air at an angle of about 30° above the horizontal. Problem (7): A ball is thrown at an angle of 60° with an initial speed of 200 m/s. (Neglect the air resistance.) (a) How long is the ball in the air? (b) Find the maximum horizontal distance traveled by the ball. (c) What is the maximum height reached by the ball? Solution: We choose the origin to be the ball's initial position so that $x_0=y_0=0$. The given data is (i) The projection angle: 60°.



PHYSICS 12 PROJECTILE MOTION WORKSHEET 2

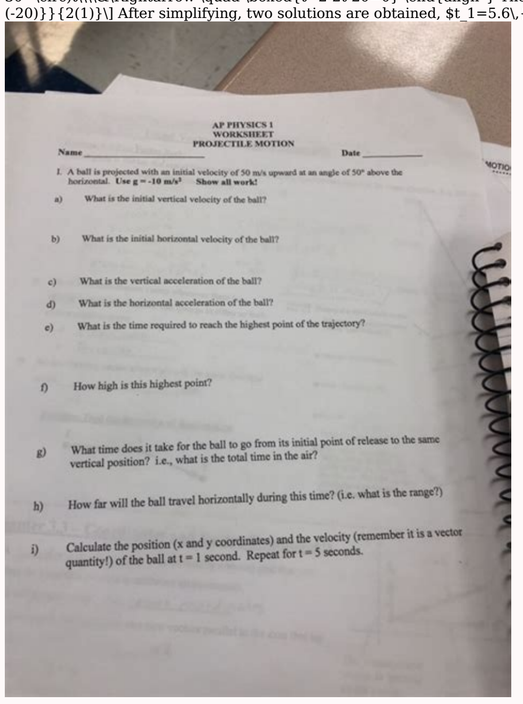
1. A rock is thrown horizontally from a cliff at 25 m/s.
   a) What will its horizontal and vertical velocities be after 2.0 s?
   b) What will its velocity be (magnitude and direction) after 3.0 s?
   c) What will its displacement be after 3.0 s?
2. A ball is projected horizontally with velocity '-v' m/s from a point 245 m above the ground.
   a) How long does it take to reach the ground?
   b) If it strikes the ground 84 m horizontally from the point of projection, what is the value of v?
3. A boy standing on top of a hill throws a stone horizontally. The stone hits the ground at the foot of the hill 2.5 s later. How high is the hill?
4. A projectile is shot upward at a 60° angle with the ground at 65 m/s.
   a) What are the vertical and horizontal components of its velocity?
   b) How far has the projectile gone horizontally after 4.0 seconds?
5. The muzzle velocity of a projectile fired from a gun has an upward component of 49 m/s and a horizontal component of 60 m/s.
   a) What maximum height does the projectile reach?
   b) How far forward does it go? (assume a level surface)
6. A bullet is fired from a height of 45 m and hits the ground 2000 m away. With what velocity does the bullet leave the gun?
7. A projectile is fired at 12.5 m/s at an angle of 53.1° with the horizontal from a point 75.0 m above the ground.
   a) How long does it take to reach the ground?
   b) What maximum height does it reach?
   c) What horizontal distance does it travel before striking the ground?
   d) With what velocity does it strike the ground?
8. A projectile is fired at an angle θ above the horizontal from a point 80 m above the ground. If the vertical component of the initial velocity is 30 m/s upwards,
   a) how long does the projectile take to land?
   b) calculate the angle θ if the projectile travels 576 m.
9. A stone is projected upwards at 30° to the horizontal from a point 175 m above the ground, with initial velocity 20 m/s.
   a) How long does the stone take to reach the ground?
   b) What is the range of the projectile?
   c) What is the velocity of the object when it strikes the ground?

1 a) 25 m/s, 19.6 m/s down b) 38.0 m/s @ 49.6° down c) 87 m @ 30.5° down 2 a) 7.1 s b) 12 m/s 3. 31 m

(ii) Initial speed : $v_0=200\,{\rm m/s}$. (a) The initial and final points of the ball are at the same level, i.e., $y-y_0=0$. Thus, the total time the ball is in the air is found by setting $y=0$ in the projectile equation $y=-\frac 12 gt^2+v_{0y}t$ and solving for time t as below \begin{align*} y&=-\frac 12 gt^2+(v_0\sin\theta)t\\\\0&=-\frac 12 (9.8)t^2+(200)(\sin 60^\circ)t\\\\Rightarrow \quad & \boxed{(-4.9t+100\sqrt{3})t=0} \end{align*} The above expression has two solutions for t. One is the initial time, $t_1=0$, and the other is computed as $t_2=35.4\,{\rm s}$. Hence, the ball has been in the air for about 35 s. (b) The horizontal distance is called the range of the projectile. By inserting the above time (total flight time) into the horizontal distance projectile equation $x=v_{0x}t$, we can find the desired distance traveled. \begin{align*} x&=(v_0\cos\theta)t\\&=(200)(\cos 60^\circ)(35.4)\\&=3540 \quad {\rm m}\end{align*} Therefore, the ball hits the ground 3540 meters away from the throwing point. (c) Using the projectile equation $v_y^2-v_{0y}^2=-2g(y-y_0)$, setting $v_y=0$ at the highest point of the path, and solving for the vertical distance y, the maximum height is found as follows \begin{align*} v_y^2-v_{0y}^2&=-2g(y-y_0)\\0-(200\sin 60^\circ)^2&=-2(9.8)y\\\Rightarrow y&=1531\quad {\rm m}\end{align*} Another method: As mentioned above, the ball hits the ground at the same level as before, so by knowing the total flight time and halving it, we can find the time it takes the ball to reach the highest point of its trajectory. Therefore, by setting the half of the total flight time in the following projectile kinematic formula and solving for y, we can find the maximum height as \begin{align*} y-y_0&=-\frac 12 gt^2+(v_0\sin\theta)t\\\\y&=-\frac 12 (9.8)(17.7)^2+(200\sin60^\circ)(17.7)\\\\&=1531\quad {\rm m}\end{align*} Hence, the ball reaches 1531 meters above the launch point. Problem (8): What are the horizontal range and maximum height of a bullet fired with a speed of 20 m/s at 30° above the horizontal? Solution: first, find the total flight time, then insert it into the horizontal displacement projectile equation $x=v_{0x}t$ to find the range of the bullet. Because the bullet lands at the same level as the original, its vertical displacement is zero, $y-y_0=0$, in the following projectile formula we can find the total flight time \begin{align*} y-y_0&=-\frac 12 gt^2+(v_0\sin\theta)t\\\\0&=-\frac 12 (9.8)t^2+(20)(\sin30^\circ)t\\\\ \Rightarrow & (-4.9t+10)t=0\end{align*} Solving for time t gives two solutions, one is the initial time $t_1=0$, and the other is $t_2=1.02\,{\rm s}$.

Thus the total time of flight is 2.04 s. Therefore, the maximum horizontal distance traveled by the bullet, which is defined as the range of the projectile, is calculated as \begin{align*} x&=(v_0\cos\theta)t\\&=(20\cos 30^\circ)(2.04)\\&=35.3\quad {\rm m}\end{align*} Hence, the bullet is landed about 17 m away from the launch point. Because the air resistance is negligible and the bullet lands at the same height as the original, the time it takes to reach the highest point of its path, is always half the total flight time. On the other hand, recall that the vertical component of velocity at the maximum height is always zero, i.e., $v_y=0$. By inserting these two notes into the following projectile equation, we have \begin{align*} y&=-\frac 12 gt^2+(v_0\sin\theta)t\\\\&=-\frac 12 (9.8)(1.02)^2+(20\sin 30^\circ)(1.02)\\\\&=5.1\quad {\rm m}\end{align*} We could also simply use the kinematic equation $v_y^2-v_{0y}^2=-2g(y-y_0)$, to find the maximum height as below \begin{align*} v_y^2-(v_0 \sin \theta)^2 &=-2g(y-y_0) \\ 0-(20\sin 30^\circ)^2 &=-2(9.8)H\\ \Rightarrow H&= 5.1\quad {\rm m} \end{align*} I think the second method is much simpler. Problem (9): A projectile is fired horizontally at a speed of 8 m/s from an 80-m-high cliff. Find (a) The velocity just before the projectile hits the ground. (b) The angle of impact. Solution: In this problem, the angle of the projectile is zero because it is fired horizontally. The velocity at each point of a projectile trajectory (path) is obtained by the following formula: \[v=\sqrt{v_x^2+v_y^2}\] where v_x and v_y are the horizontal and vertical components of the projectile's velocity at any instant of time. (a) Recall that the horizontal component of the projectile's velocity is always constant and, for this problem, is found as \begin{align*} v_x&=v_0\cos\theta\\&=8\times \cos 0^\circ\\&=8\quad {\rm m/s}\end{align*} To find the vertical component of the projectile velocity at any moment, $v_y=v_0\sin\theta-gt$, we should find the time taken to that point. In this problem, that point is located just before striking the ground, whose coordinates are $y=-80\,{\rm m}, x=?$. Because it is below the origin, which is assumed to be at the firing point, we inserted a minus sign. Because displacement in the vertical direction is known, we can use the projectile formula for vertical distance. By setting $y=-80$ into it and solving for the time t needed the projectile reaches the ground, we get \begin{align*} y&=-\frac 12 gt^2+(v_0\sin\theta)t\\\\-80&=-\frac 12 (9.8)t^2+(8\times \sin 0^\circ)t\\\\Rightarrow t&=\sqrt{\frac{2(80)}{9.8}}\\\\&=2.86\quad {\rm s}\end{align*} Now insert this time into the y-component of the projectile's velocity to find v_y just before hitting the ground \begin{align*} v_y&=v_0\sin\theta-gt\\ &=8\sin 0^\circ-(9.8)(2.86)\\&=-28\quad {\rm m/s}\end{align*} Now that both components of the velocity are available, we can compute its magnitude as below \begin{align*} v&=\sqrt{v_x^2+v_y^2}\\\\&=\sqrt{8^2+(-28)^2}\\\\&=29.1\quad {\rm m/s}\end{align*} Therefore, the projectile hits the ground at a speed of 29.1 m/s. (b) At any instant of time, the velocity of the projectile makes some angle with horizontal whose magnitude is obtained as the following formula \[\alpha=\tan^{-1}\left(\frac{v_y}{v_x}\right)\] Substituting the above values into this formula we get \[\alpha =\tan^{-1}\left(\frac{-28}{8}\right)=-74^\circ\] Therefore, the projectile hits the ground at an angle of 74° below the horizontal. To find the components of a vector in physics, refer to the following: Vectors problems with solutions or Vector problems in AP Physics 1. Problem (10): From a cliff of 100-m high, a ball is kicked at 30° above the horizontal with a speed of $20\,{\rm m/s}$. How far from the base of the cliff did the ball hit the ground? (Assume $g=10\,{\rm m/s^2}$). Solution: Again, similar to any projectile motion problem, we first select a coordinate system and then draw the path of the projectile as shown in the figure below, We choose the origin to be at the kicking point above the cliff, setting $x_0=y_0=0$ in the kinematic equations. The coordinate of the hitting point to the ground is $y=-100\,{\rm m}, x = ?$. A negative is inserted because the final point is below the origin.

Now, we find the common quantity in projectile motions- that is, the time between the initial and final points, called total flight time. To find the total time the ball was in the air, we can use the vertical equation and solve for the unknown t as follows \begin{align*} y&=-\frac 12 gt^2 +(v_0\sin \theta)t \\\\ -100&=-\frac 12 (10) t^2+(20\sin 30^\circ)t\\\\&\Rightarrow \quad \boxed{t^2-2t-20=0} \end{align*} The solutions of a quadratic equation $at^2+bt+c=0$ are found by the formula below \[t=\frac{-b\pm\sqrt{b^2-4ac}}{2a}\] By matching the above constant coefficients with the standard quadratic equation, we can find the total time as below \[t=\frac{-(-2)\pm\sqrt{(-2)^2-4(1)(-20)}}{2(1)}\] After simplifying, two solutions are obtained, $t_1=5.6\,{\rm s}$ and $t_2=-3.6\,{\rm s}$. It is obvious that time cannot be negative in physics, so the acceptable answer is t_1.



AP PHYSICS 1
WORKSHEET
PROJECTILE MOTION

Name _____ Date _____

I. A ball is projected with an initial velocity of 50 m/s upward at an angle of 50° above the horizontal. Use g = -10 m/s² Show all work!

a) What is the initial vertical velocity of the ball?

b) What is the initial horizontal velocity of the ball?

c) What is the vertical acceleration of the ball?

d) What is the horizontal acceleration of the ball?

e) What is the time required to reach the highest point of the trajectory?

f) How high is this highest point?

g) What time does it take for the ball to go from its initial point of release to the same vertical position? i.e., what is the total time in the air?

h) How far will the ball travel horizontally during this time? (i.e. what is the range?)

i) Calculate the position (x and y coordinates) and the velocity (remember it is a vector quantity!) of the ball at t = 1 second. Repeat for t = 5 seconds.

It is the time it takes the ball to travel in the vertical direction.

On the other hand, it is also the time it takes the ball to travel the horizontal distance between kicking and hitting points. We insert this time into the horizontal equation to find the horizontal distance traveled, which is known as the range of the projectile.

\begin{align*} x&=(v_0\cos \theta)t\\ &=(20)(\cos 30^\circ)(5.6)\\&=97\quad {\rm m}\end{align*} In the following, some projectile motion problems for the AP Physics 1 exam are presented.

AP physics MCQ: A cannonball is fired from the top of a $200\,{\rm m}$ cliff with a speed of $60\,{\rm m/s}$ at an angle of 60° above the horizontal. Where does the ball land closest to which of the following choices? (Neglect air resistance.)} (a) 90m (b) 402 m (c) 151 m (d) 200 m Solution: The horizontal distance from the point where the cannonball fired is wanted, $x=?$. The appropriate kinematic equation for this is \[x=(v_0\cos\theta)t\] The only thing we need is the total time the ball is in the air before landing. If we take the firing point as the origin, then the cannonball lands $200\,{\rm m}$ below the origin.

So, the ball's vertical displacement is $\Delta y=-200\,{\rm m}$. Set this in the vertical displacement equation, $\Delta y=-\frac 12 gt^2+(v_0\sin\theta)t$, and solve for t. Keep reading the pdf version of this page.

AP physics MCQ: Water comes out of the head of a hose at the speed of $6\,{\rm m/s}$. At what angle(s) should we point the hose so that the water stream strikes the ground $2.5\,{\rm m}$ away? (a) 68° (b) 22° (c) $68^\circ\, ,\, 22^\circ$ (d) 32° Solution: The initial velocity and maximum horizontal distance are given, and we want the angle θ.

The water hits the ground at the same elevation as the nozzle, so its vertical displacement is zero, $\Delta y=0$. Substitute this into the kinematic equation below and get the first required equation \begin{align*} \Delta y &=-\frac 12 gt^2 +(v_0 \sin\theta)t\\\\ 0&=-\frac 12 (10)t^2 +(6\sin\theta)t \\\\&=-5t^2 + 6t\sin\theta \\\\&=t(-5t+6\sin\theta) \end{align*} The above relation gives us the first equation \[\boxed{6\sin\theta=5t}\] Now, we use the horizontal displacement formula for projectile and set $x=2.5\,{\rm m}$. Thus, \begin{gather*} x=(v_0\cos\theta)t\\\\ 2.5=(6\cos\theta)t \\\\ \Rightarrow \boxed{6t\cos\theta=2.5} \end{gather*} Dividing these two boxed equations, we have \begin{gather*} \frac{6\sin\theta}{6t\cos\theta}=\frac{5t}{2.5} \\\\ \boxed{\tan\theta=2t^2\, ,\quad (I)}\end{gather*} This is the only equation that we can find with the given information. Note that t in the all above equations is the total time the water has been in the air. Keep reading the pdf version of this article. Author: Dr. Ali Nemati Date Published: 6/15/2021 Updated: Sep 16, 2021 report this ad © 2015 All rights reserved.

by Physexams.com Courses Exams Flash Cards