ANSWERS - AP Physics Multiple Choice Practice – Kinematics

	Solution	Answer
1.	Total distance = 60 miles, total time = 1.5 hours; average speed = total distance/total time	B
2.	Area bounded by the curve is the displacement By inspection of particle A the positive area between 0 and 1s will be countered by an equal negative area between 1 and 2s.	B
3.	Constant non-zero acceleration would be a straight line with a non-zero slope	D
4.	Area bounded by the curve is the displacement By inspection of particle A the positive area between 0 and 1s will be countered by an equal negative area between 1 and 2s.	A
5.	Area bounded by the curve is the displacement By inspection the negative area between 0 and 1s will be countered by an equal negative area sometime between 1 and 2s.	C
6.	Between 0 and 1 s; $d_1 = vt$; from 1 to 11 seconds; $d_2 = v_0t + ½ at^2$; $d = d_1 + d_2$	C
7.	Since the slope is positive and constant, so is the velocity, therefore the acceleration must be zero	A
8.	For a horizontal projectile, the initial speed does not affect the time in the air. Use $v_{0y} = 0$ with $10 \text{ m} = ½ gt^2$	C
9.	The time in the air for a horizontal projectile is dependent on the height and independent of the initial speed. Since the time in the air is the same at speed v and at speed 2v, the distance (d = vt) will be twice as much at a speed of 2v	C
10.	Average velocity = total displacement/total time; magnitude of total displacement = 500 m (3-4-5 triangle) and total time = 150 seconds	B
11.	The acceleration is constant and negative which means the slope of the velocity time graph must have a constant negative slope. (Only one choice has the correct acceleration anyway)	D
12.	From rest, $h = ½ gt^2$	C
13.	At the top of its path, the vertical component of the velocity is zero, which makes the speed at the top a minimum. With symmetry, the projectile has the same speed when at the same height, whether moving up or down.	D
14.	g points down in projectile motion. Always.	E
15.	For a horizontal projectile; $h = ½ gt^2$ (initial vertical component of velocity is zero)	E
16.	At *every* point of a projectiles free-fall, the acceleration is the acceleration due to gravity	E
17.	Average speed = total distance/total time = (8 m – 2 m)/(1 second)	D
18.	For a horizontal projectile; $h = ½ gt^2$ (initial vertical component of velocity is zero)	C
19.	The area under the curve is the displacement. There is more area under the curve for Car X.	A
20.	Area under the curve is the displacement. Car Y is moving faster as they reach the same point.	B
21.	Uniformly accelerated means the speed-time graph should be a stright line with non-zero slope. The corresponding distance-time graph should have an increasing slope (curve upward)	E
22.	From the equation $d = ½ at^2$, displacement is proportional to time squared. Traveling from rest for twice the time gives 4 times the displacement (or 4 m). Since the object already travelled 1 m in the first second, during the time interval from 1 s to 2 s the object travelled the remaining 3 m	C
23.	To travel straight across the river, the upstream component of the boat's velocity must cancel the current. Since the speed of the current is the same as the speed of the boat, the boat must head directly upstream to cancel the current, which leaves no component across the river	E

24. v_{iy} = 200 m/s sin 30º = 100 m/s. At maximum height $v_y = 0$. Use $v_y^2 = v_{iy}^2 + 2gh$ C

25. Acceleration is proportional to Δv. $\Delta v = v_2 - v_1 = v_2 + (-v_1)$ E

26. From a height of 45 m (= ½ gt^2) it takes 3 seconds to strike the ground. In that time, the ball thrown traveled 30 m. v = d/t B

27. 9.8 m/s^2 can be thought of as a change in speed of 9.8 m/s *per second*. A

28. v_i = 0 m/s; v_f = 30 m/s; t = 6 s; $\bar{v} = \dfrac{v_i + v_f}{2} = \dfrac{d}{t}$ D

29. velocity of package relative to observer on ground $v_{pg} = v_1 = \searrow$ D

velocity of package relative to pilot $v_{pp} = v_2 = \downarrow$

velocity of pilot relative to ground $v_{po} = \longrightarrow$

Putting these together into a right triangle yields $v_{pg}^2 + v_2^2 = v_1^2$

30. While the object momentarily stops at its peak, it never stops accelerating downward. D

31. Maximum height of a projectile is found from $v_y = 0$ at max height and $v_y^2 = v_{iy}^2 + 2gh$ and gives $h_{max} = v_{iy}^2/2g = (v_i \sin\theta)^2/2g$. Fired straight up, θ = 90º and we have $v_i = \sqrt{2gh}$ C

Plugging this initial velocity into the equation for a 45º angle (sin 45º = $\dfrac{1}{\sqrt{2}}$) gives

$h_{new} = (\sqrt{2gh}\,\dfrac{1}{\sqrt{2}})^2/2g = h/2$

32. g points down in projectile motion. Always. C

33. horizontal velocity v_x remains the same thorughout the flight. g remains the same as well. E

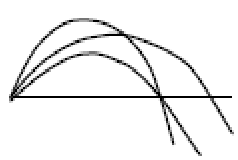
34. A velocity-time graph represents the *slope* of the displacement-time graph. Analyzing the v-t graph shows an increasing slope, then a constant slope, then a decreasing slope (to zero) D

35. For a dropped object: d = ½ gt^2 D

36. For a horizontal projectile, the initial speed does not affect the time in the air. Use $v_{0y} = 0$ with 10 m = ½ gt^2 to get t = $\sqrt{2}$ For the horzontal part of the motion; v = d/t C

37. A velocity-time graph represents the *slope* of the displacement-time graph. Analyzing the v-t graph shows a constant slope, then a decreasing slope to zero, becoming negative and increasing, then a constant slope. Note this is an analysis of the *values* of v, not the slope of the graph itself A

38. By process of elimination (A and B are unrealistic; C is wrong, air resistance should decrease the acceleration; E is irrelevant) D

39. 

The 45° angle gives the maximum horizontal travel to the original elevation, but the smaller angle causes the projectile to have a greater horizontal component of velocity, so given the additional time of travel allows such a trajectory to advance a greater horizontal distance. In other words given enough time the smaller angle of launch gives a parabola which will eventual cross the parabola of the 45° launch. C

40. The area under the curve of an acceleration-time graph is the change in speed. D

41. In the 4 seconds to reach the ground, the flare travelled 70 m/s × 4 s = 280 m horizontally. D

42. In the 4 seconds to reach the ground, the flare travelled 70 m/s × 4 s = 280 m horizontally. The plane travelled d = $v_i t + ½ at^2$ = (70 m/s)(4 s) + (0.5)(0.75 m/s^2)(4 s)^2 = 280 m + 6 m, or 6 m ahead of the flare. B

43. Positive velocity = positive slope. Negative acceleration = decreasing slope (or downward curvature E

44. The slope of the line represents her velocity. Beginning positive and constant, going to zero, then positive and larger than the initial, then negative while the line returns to the time axis B

45. Dropped from a height of 9.8 m, the life preserver takes (9.8 m = ½ gt^2); t = 1.4 seconds to reach the water. In that 1.4 seconds the swimmer covered (6.0 m – 2.0 m) = 4.0 m meaning the water speed is (4.0 m)/(1.4 s) D

46. The ball takes time *T*/2 to reach height *H*. Using $v_y = 0$ at maximum height and $\bar{v} = \frac{v_i + v_f}{2} = \frac{d}{t}$ gives the initial speed as 4*H*/*T*. In addition from the top H = ½ g(T/2)^2 = $gT^2/8$. Plugging in a time T/4 gives d = (4H/T)(T/4) + ½ (–g)(T/4)^2 = H – ¼ (gT^2/8) = ¾ H E

47. While the object momentarily stops at its peak, it never stops accelerating downward. Without air resistance, symmetry dictates time up = time down. With air resistance considered, the ball will have a larger average velocity on the way up and a lower average velocity on the way down since it will land with a smaller speed than it was thrown, meaning the ball takes longer to fall. A

48. Total distance = d. Time for first ¾ d is t_1 = (¾d)/v = 3d/4v. Time for second part is t_2 = (¼ d)/(½ v) = 2d/4v. Total time is then $t_1 + t_2$ = 5d/4v. Average speed = d/(5d/4v) B

49. Positive acceleration is an increasing slope (including negative slope increasing toward zero) or upward curvature C

50. With air resistance, the acceleration (the slope of the curve) will decrease toward zero as the ball reached terminal velocity. Note: without air resistance, choice (A) would be correct D

51. Since for the first 4 seconds, the car is accelerating positively the entire time, the car will be moving fastest just beofre slowing down after t = 4 seconds. C

52. The area under the curve represents the change in velocity. The car begins from rest with an increasing positive velocity, after 4 seconds the car begins to slow and the area under the curve from 4 to 8 seconds couters the increase in velocity form 0 to 4 seconds, bringing the car to rest. However, the car never changed direction and was moving away from its original starting position the entire time. E

53. The ball will land with a speed given by the equaion $v^2 = v_i^2 + 2gH$ or v = $\sqrt{2gH}$. Rebounding with ¾ the speed gives a new height of v_f = 0 = (¾ $\sqrt{2gH}$)^2 + 2(–g)h_{new} C

54. The velocity-time graph should represent the slope of the position-time graph and the acceleration-time graph should represent the slope of the velocity-time graph C

55. It's a surprising result, but while both the horizontal and verticla components change at a given height with varying launch angle, the *speed* $(v_x^2 + v_y^2)^{1/2}$ will be independent of α (try it!) C

56. $v_f^2 = v_i^2 + 2ad$ B

57. d_1 = (+7 m/s)(2 s) + ½ (–10 m/s^2)(2 s)^2; d_1 = (–7 m/s)(2 s) + ½ (–10 m/s^2)(2 s)^2 C

58. Range of a projectile $R = (v_i^2 \sin 2\theta)/g$ and maximum range occurs at $\theta = 45°$, which gives $v_i = \sqrt{Rg}$. Maximum height of a projectile is found from $v_y = 0$ at max height and $v_y^2 = v_{iy}^2 + 2gh$ and gives $h_{max} = v_{iy}^2/2g = (v_i \sin \theta)^2/2g$. Maximum range occurs at 45º, which gives $h = (Rg)(\sin 45)^2/2g$ — B

59. $v_f^2 = v_i^2 + 2ad$ — D

60. The diagonal of a face of the cube is $3\sqrt{2}$ m. The diagonal across the cube itself is the hypoteneuse of this face diagonal and a cube edge: $\sqrt{(3\sqrt{2})^2 + 3^2}$ — A

61. Instantaneous velocity is the slope of the line at that point — A

62. Displacement is the area under the curve. Maximum displacement is just before the car turns around at 2.5 seconds. — D

63. Range of a projectile $R = (v_i^2 \sin 2\theta)/g$ and maximum range occurs at $\theta = 45°$, which gives $v_i = \sqrt{Rg}$. Using $\theta = 30°$ gives $R_{new} = R \sin 60°$ — A

64. (advanced question!) The time for one bounce is found from $-v = v + (-g)t$ which gives $t = 2v/g$. We are summing the time for all bounces, while the velocity (and hence the time) converge in a geometric series with the ratio $v_{n+1}/v_n = r < 1$ to $\frac{1}{1-r}$ — A

65. The acceleration is the slope of the curve at 90 seconds. — B

66. From the equation $d = ½ at^2$, displacement is proportional to time squared. Traveling from rest for twice the time gives 4 times the displacement (or 4 h). Since the object already travelled h in the first second, during the time interval from 1 s to 2 s the object travelled the remaining 3h — C

67. $d = v_i t + ½ gt^2$ — D

68. The relative speed between the coyote and the prairie dog is 14.5 m/s. To cover the 45 m distance between them will take $t = d/v = (45 \text{ m})/(14.5 \text{ m/s})$ — B

69. For the first part of the trip (the thrust): $d_1 = v_i t + ½ at^2 = 0 \text{ m} + ½ (50 \text{ m/s}^2)(2 \text{ s})^2 = 100 \text{ m}$
For the second part, we first find the velocity after the thrust $v = at = 100$ m/s and at the maximum height $v_f = 0$, so to find d_2 we use $v_f^2 = v_i^2 + 2ad_2$ which gives $d_2 = 510$ m — C

70. Total displacement west = 1100 m; total displacement south = 400 m. Use the Pythagorean theorem. — C

71. For a horizontal projectile ($v_{iy} = 0$ m/s) to fall 1 m takes (using $1 \text{ m} = ½ gt^2$) 0.45 seconds. To travel 30 m in this time requires a speed of $d/t = (30 \text{ m})/(0.45 \text{ s})$ — D

72. Maximum height of a projectile is found from $v_y = 0$ m/s at max height and $(0 \text{ m/s})^2 = v^2 + 2gh$ and gives $h = v^2/2g$
The height at which the projectile is moving with half the speed is found from $(½v)^2 = v^2 + 2(-g)d$ which gives $d = 3v^2/8g = 0.75$ h — E

73. Looking at choices A, D and E eliminates the possibility of choices B and C (each ball increases its speed by 9.8 m/s each second, negating those choices anyway). Since ball A is moving faster than ball B at all times, it will continue to pull away from ball B (the relative speed between the balls separates them). — E

74. Since they all have the same horizontal component of the shell's velocity, the shell that spends the longest time in the air will travel the farthest. That is the shell launched at the largest angle (mass is irrelevant). — D

75. This is merely asking for the horizontal range of a horizontal projectile. The time in the air is found from the height using h = ½ gt^2 which gives $t = \sqrt{\frac{2h}{g}}$. The range is found using d = vt — E

76. Flying into the wind the airliners speed relative to the ground is 500 km/h – 100 km/h = 400 km/h and a 3000 km trip will take t = d/v = 7.5 hours. Flying with the wind the airliners speed relative to the ground is 500 km/h + 100 km/h = 600 km/h and a 3000 km trip will take t = d/v = 5 hours making the total time 12.5 hours. — C

77. The horizontal component of the velocity is 28.3 m/s cos 60º = 14.15 m/s. If the ball is in the air for 5 seconds the horizontal displacement is $x = v_x t$ — D

78. since (from rest) d = ½ gt^2, distance is proportional to time squared. An object falling for twice the time will fall four times the distance. — D

79. $\bar{v} = \frac{v_i + v_f}{2} = \frac{d}{t}$ — A

80. v_f = –40 m/s (negative since it is moving down when landing). Use $v_f = v_i + (-g)t$ — B

81. For a horizontal projectile (v_{iy} = 0 m/s) to fall 0.05 m takes (using 0.05 m = ½ gt^2) 0.1 seconds. To travel 20 m in this time requires a speed of d/t = (20 m)/(0.1 s) — D

82. 9.8 m/s^2 means the speed changes by 9.8 m/s each second — B

83. Once released, the package is in free-fall (subject to gravity only) — D

84. For the first part v = at = 8.0 m/s and d = ½ at^2 = 40 m. In the second part of the trip, the speed remains at 8 m/s, and travels an additional d = vt = 80 m — C

85. The definition of termincal velocity is the velocity at which the force of air friction balances the weight of the object and the object *no longer accelerates*. — B

86. To reach a speed of 30 m/s when dropped takes (using v = at) about 3 seconds. The distance fallen after three seconds is found using d = ½ at^2 — C

87. 9.8 m/s^2 means the speed changes by 9.8 m/s each second (in the downward direction) — D

88. Total distance = 800 km. Times are (400 km)/(80 km/h) = 5 hours and (400 km)/(100 km/h) = 4 hours. Average speed = total distance divided by total time. — B

89. $\Delta v = at$ — B

90. 9.8 m/s^2 means the speed changes by 9.8 m/s each second — D

91. Velocity is a vector, speed is a scalar — B

92. Choices A, B, C and E all refer to vectors — D

93. Falling on the Moon is no different conceptually than falling on the Earth — C

94. Since the line is above the t axis for the entire flight, the duck is always moving in the positive (forward) direction, until it stops at point D — D

95. One could analyze the graphs based on slope, but more simply, the graph of position versus time should represent the actual path followed by the ball as seen on a platform moving past you at constant speed. — C

96. Other than the falling portions (a = –9.8 m/s^2) the ball should have a “spike” in the acceleration when it bounces due to the rapid change of velocity from downward to upward. — B

97. The same average speed would be indicated by the same distance travelled in the time interval — C

98. At t_3, car #1 is ahead of car #2 and at t_4, car #1 is behind car #2. They were in the same position somewhere in between — D

99. Average speed = (total distance)/(total time). Cars #2 and #3 travelled the same distance. — B

100. If you look at the distance covered in each time interval you should nitce a pattern: 2 m, 6 m, 10 m, 14 m, 18 m; making the distance in the next second 22 m. — C

101. Instantaneous speed is the slope of the line at that point. — B

102. A non-zero accleeration is inidcated by a curve in the line — E

103. Net displacement north = 300 miles sin 30º = 150 miles — C
Net displacement east = (300 miles cos 30º – 600 miles) = – 340 miles, or 340 miles west.
Angle north of west is $\tan^{-1}(\frac{150 miles}{340 miles})$

104. Maximum height of a projectile is found from v_y = 0 m/s at max height and $(0\ m/s)^2 = v^2 + 2gh$ and gives $h = v^2/2g$. At twice the initial speed, the height will be 4 times as much — C

105. Average speed = total distance divided by total time = (0.48 m)/(0.2 s) — E

106. $d = ½ at^2$ (use any point) — E

107. $v = v_i + at$ — B

108. Acceleration is the slope of the line segment — C

109. Displacement is the area under the line — E

110. v_i = 30 m, v_f = 0, d = 45 m; $\bar{v} = \frac{v_i + v_f}{2} = \frac{d}{t}$ — D

111. In a vacuum, there is no air resistance and hence no terminal velocity. It will continue to accelerate. — E

112. A projectile launched at a smaller angle does not go as high and will fall to the ground first. — B

113. $v_x = v_i \cos \theta$ — C

114. Velocity is the slope of the line. — D

115. Positive acceleration is an upward curvature — D

116. Average acceleration = $\Delta v/\Delta t$ — E

117. $d = ½ at^2$ — E

118. Acceleration is the slope of the line segment — C

119. Displacement is the area between the line and the t-axis. Area is negative when the line is below the t-axis. — B

120. After two seconds, the object would be above it's original position, still moving upward, but the acceleration due to gravity is always pointing down — B

121. Constant speed is a constant slope on a position-time graph, a horizontal line on a velocity time graph or a zero value on an acceleration-time graph — D

122. Average speed = total distance divided by total time = (7 cm)/(1 s) — B

123. $d = ½ at^2$ (use any point) — C

124. Maximum height of a projectile is found from $v_y = 0$ m/s at max height and $(0 \text{ m/s})^2 = v^2 + 2gh$ and gives $h = v^2/2g$. Mass is irrelevant. Largest initial speed = highest. C

125. Using $d = ½ at^2$ shows the height is proportional to the time squared. ½ the maximum height is $\frac{1}{\sqrt{2}}$ times the time. B

126. Stopping distance is found using $v_f = 0 = v_i^2 + 2ad$ which gives $d = v_i^2/2a$ where stopping distance is proportional to initial speed squared. A

127. $v_f = v_i + gt$ B

128. Moving away from the origin will maintain a negative position and velocity. Slowing down indicates the acceleration is opposite in direction to the velocity. B

129. The arrow travels equal horizontal distances in equal amounts of time. The distance fallen is proportional to time squared. The arrow will have fallen a total of 0.8 m in the next 5 m horizontally, or an *additional* 0.6 m. A

130. Tan 53º = h/(8 m) B

131. $d = ½ at^2$ C

132. Maximum height of a projectile is found from $v_y = 0$ at max height and $v_y^2 = v_{iy}^2 + 2gh$ and gives $h_{max} = v_{iy}^2/2g = (v_i \sin\theta)^2/2g$ B

133. Acceleration is the slope of the line D

134. Since the first rock is always traveling faster, the relative distance between them is always increasing. A

135. Stopping distance is found using $v_f = 0 = v_i^2 + 2ad$ which gives $d = v_i^2/2a$ where stopping distance is proportional to initial speed squared. B

136. At an angle of 120º, there is a component of the acceleration perpendicular to the velocity causing the direction to change and a component in the opposite direction of the velocity, causing it to slow down. B

137. $d = ½ at^2$ C

138. The displacement is directly to the left. The average velocity is proportional to the displacement B

139. The velocity is initially pointing up, the final velocity points down. The acceleration is in the same direction as $\Delta v = v_f + (-v_i)$ D

140. The car is the greatest distance just before it reverses direction at 5 seconds. C

141. Average speed = (total *distance*)/(total time), the total distance is the magnitude of the area under the line (the area below the t-axis is considered positive) D

142. Speed is the slope of the line. C

143. velocity is pointing tangent to the path, acceleration (gravity) is downward. A

144. Average speed = (total *distance*)/(total time) D

145. To travel 120 m horizontally in 4 s gives $v_x = 30$ m/s. The time to reach maximum height was 2 seconds and $v_y = 0$ at the maximum height which gives $v_{iy} = 20$ m/s. $v_i = \sqrt{v_x^2 + v_{iy}^2}$ C

146. The relative speed between the two cars is $v_1 - v_2 = (60 \text{ km/h}) - (-40 \text{ km/h}) = 100$ km/h. They will meet in $t = d/v_{relative} = 150 \text{ km}/100 \text{ km/h}$ A

147. Acceleration is independent of velocity (you can accelerate in any direction while traveling in a ny direction). E

148. $12/4 = 3$, now the units: $M = 10^6$, $T = 10^{12}$: $M/T = 10^{-6}$ = micro (μ) B

149. Acceleration is independent of velocity (you can accelerate in any direction while traveling in a ny direction). If the accleration is in the same direction as the velocity, the object is speeding up. E

150. As the first bales dropped will always be traveling faster than the later bales, their relative velocity will cause their separation to always iincrease. A

151. Horizontally, the bales will all travel at the speed of the plane, as gravity will not affect their horizontal motion. D = vt = (50 m/s)(2 seconds apart) D

152. Traveling in still water will take a time t = d/v = 2d/v. Traveling perpendicularly across the stream requires the boat to head at an angle into the current, causing the relative velocity of the boat to the shore to be less than when in still water and therefore take a longer time. Since this eliminates choice E and choices D and C are identical, that leaves A as the only single option. A

If you really want proof:
To show C and D take longer, we have the following (let the current be moving with speed w):

traveling downstream; $v_{rel} = v + w$ and time = $\dfrac{d}{v+w}$

traveling upstream; $v_{rel} = v - w$ and time = $\dfrac{d}{v-w}$

total time = $\dfrac{d}{v+w}+\dfrac{d}{v-w}=\dfrac{2dv}{v^2-w^2}=\dfrac{2d}{v-\dfrac{w^2}{v}}>\dfrac{2d}{v}$

153. When the first car starts the last lap, it will finish the race in 15 seconds from that point. In 15 seconds, the second car will travel (1 km/12 s) × 15 s = 1250 m so the first car must be at least 250 m ahead when starting the last lap to win the race. A