Physics 12
Unit 1 Kinematics

Name:

The Ultimate Vector Kinematics Assignment (9%)

9401

1.

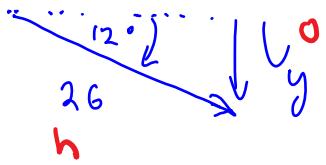
Which one of the following is a vector quantity?

A. time
B. speed
C. energy
D. displacement

2.

A car is travelling at a constant speed of 26.0 m/s down a slope which is 12.0° to the horizontal. What is the vertical component of the car's velocity?

A. 5.41 m/s
B. 9.80 m/s
C. 25.4 m/s
D. 26.0 m/s

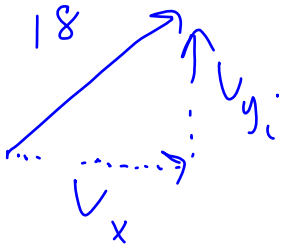


$v_y = 26 \sin 12° = 5.41$

3.

A 1.50 kg projectile is launched at 18.0 m/s from level ground. The launch angle is 26.0° above the horizontal. (Assume negligible friction.)

a) What is the maximum height reached by this projectile? **(5 marks)**



$v_{y_f} = 0 \quad a_y = -9.8\ m/s^2$

$v_{y_i} = 18 \sin 26 = 7.89$

$v_x = 18 \cos 26 = 16.18$

$v_f^2 = v_0^2 + 2ad$

$d = \dfrac{v_f^2 - v_i^2}{2a} = \dfrac{0 - 7.89^2}{-19.6} = \boxed{3.2\ m}$

How fast will the projectile be travelling when it is at its maximum height? **(2 marks)**

$v_y = 0$

$\therefore \quad v = 16.2\ m/s$

$v_x = 16.18\ m/s$

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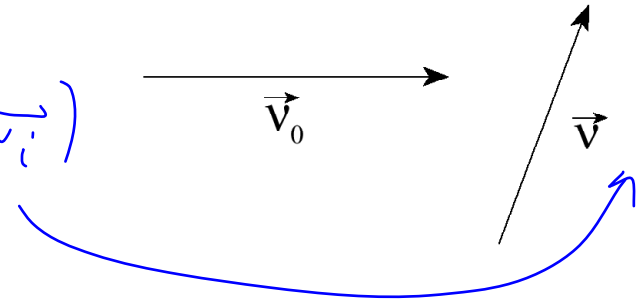
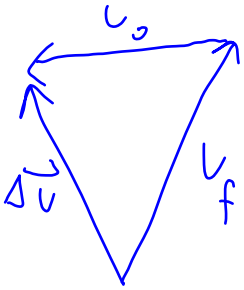
4.

Initial velocity vector $\vec{v}_0$ and final velocity vector $\vec{v}$ are shown below.

$\Delta \vec{v} = \vec{v}_f - \vec{v}_i$

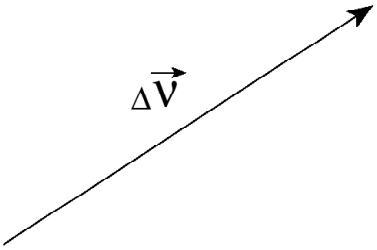
$= \vec{v}_f + (-\vec{v}_i)$



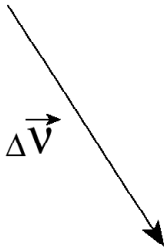


Which of the following represents the change in velocity $\Delta\vec{v}$?

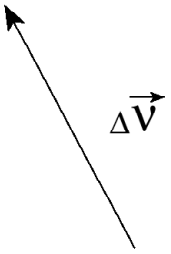
A.



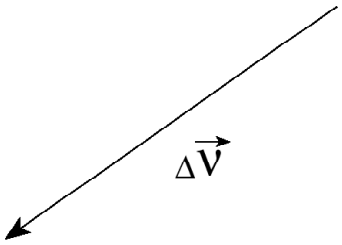
B.



C.



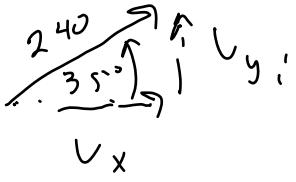
D.



5.

A projectile is launched over level ground with a speed of 240 m/s at 35° to the horizontal. If friction is negligible, what is the height of the projectile 17 s after launch?

A. 9.2×10^2 m
B. 1.9×10^3 m
C. 2.7×10^3 m
D. 5.5×10^3 m



$t = 17$ s

$v_{y_i} = 240 \sin 35$

$= 137.7$

$a_y = -9.8$ m/s^2

$t = 17$

$d_y = ?$

$d_y = v_{y_i} t + \frac{1}{2} a_y t^2$

$= (137.7)(17) - 4.9(17)^2 = \boxed{9.2\times10^2 \text{ m}}$

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6.

A passenger jet needs to reach a speed of 100 m/s on the runway for takeoff. If the runway is 2.5×10^3 m long, what minimum average acceleration from rest is needed?

A. 0.040 m/s^2
B. 2.0 m/s^2
C. 4.0 m/s^2
D. 10 m/s^2

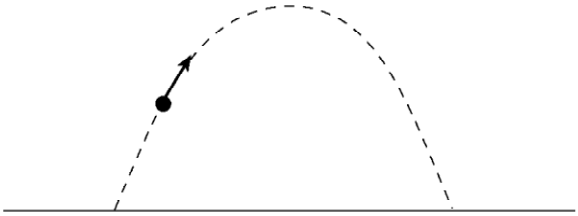
$v_f = 100$
$v_i = 0$
$d = 2.5 \times 10^3$
$a = ?$

$v_f^2 = v_i^2 + 2ad$

$a = \frac{v_f^2 - v_i^2}{2d} = \frac{100^2 - 0}{2(2500)} = 2$

7.

The diagram below shows projectile motion in the absence of friction.



This motion can be analyzed in terms of horizontal and vertical velocity components. Explain the behavior of these velocity components, using principles of physics . **(4 marks)**

Hori. Velo;

v_x : constant
$a_x = 0$ (constant)

Vert Velo

v_y : changing
$a_y = -9.8$ m/s^2 (constant)

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8.

At what speed must a ball be thrown upwards to reach a maximum height of 25 m?

A. 2.6 m/s
B. 22 m/s
C. 2.5×10^2 m/s
D. 3.1×10^3 m/s

$d_y = 25$
$a_y = -9.8$
$v_{y_i} = ?$
$v_{y_f} = 0$

$v_{y_f}^2 = v_{y_i}^2 + 2ad$

$v_{y_i} = \sqrt{v_{y_f}^2 - 2ad} = \sqrt{0 - 2(-9.8)(25)}$

$v_{y_i} = \sqrt{490} = 22$ m/s

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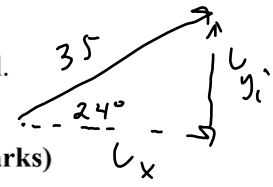
9.

A projectile is launched over level ground at 35 m/s at an angle of 24° above the horizontal. Friction is negligible.



a) What is the time of flight of this projectile? **(3 marks)**

$v_{y_i} = 35 \sin 24 = 14.24$ m/s $\quad v_{y_f} = v_{y_i} + at$

$a_y = -9.8$ m/s^2

$v_{y_f} = -14.24$

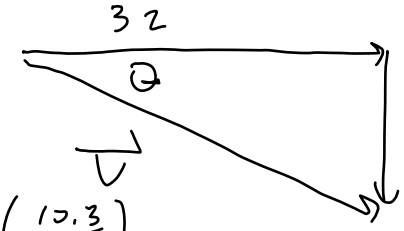
$t = \dfrac{v_{y_f} - v_{y_i}}{a} = \dfrac{-14.24 - 14.24}{-9.8} = 2.91$ s

What is the velocity (magnitude and direction) of this projectile 2.5 s after launch? **(4 marks)**

$v_x = 35 \cos 24 = 32$ m/s $\quad v_{y_f} = -10.3$

$v_{y_f} = v_{y_i} + at$

$v_{y_f} = 14.24 - 9.8(2.5)$



$\Theta = \tan^{-1}\left(\dfrac{10.3}{32}\right)$

$v = 33.6$ m/s @ 18° below horizontal

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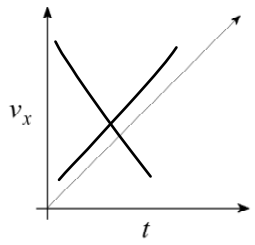
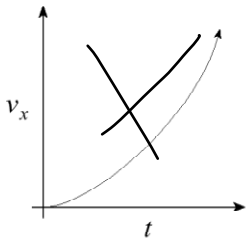
10.

Which of the following graphs represents the horizontal velocity component (v_x) versus time for a projectile thrown horizontally off a cliff? (Ignore air resistance.) v_x is CONSTANT!

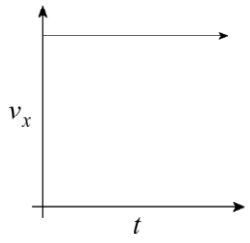
A.



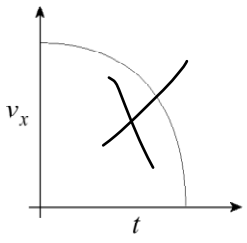
B.



C.



D.



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11.

A skier accelerates uniformly from 5.2 m/s to 12.8 m/s at 0.85 m/s^2. Find the distance she travels.

A. 7.7 m
B. 8.9 m
C. 11 m
D. 80 m

$v_i = 5.2$

$v_f = 12.8$

$a = 0.85$

$v_f^2 = v_i^2 + 2ad$

$d = \frac{v_f^2 - v_i^2}{2a} = \frac{12.8^2 - 5.2^2}{2(.85)} = 80.4$ m

12.

A projectile is launched over level ground at 35 m/s at an angle of 40° above the horizontal. What is the projectile's time of flight?

A. 2.3 s
B. 4.6 s
C. 5.5 s
D. 7.1 s

$v_{y_i} = 35 \sin 40 = 22.5$ m/s

$v_{y_f} = -22.5$ m/s

$a_y = -9.8$ m/s^2

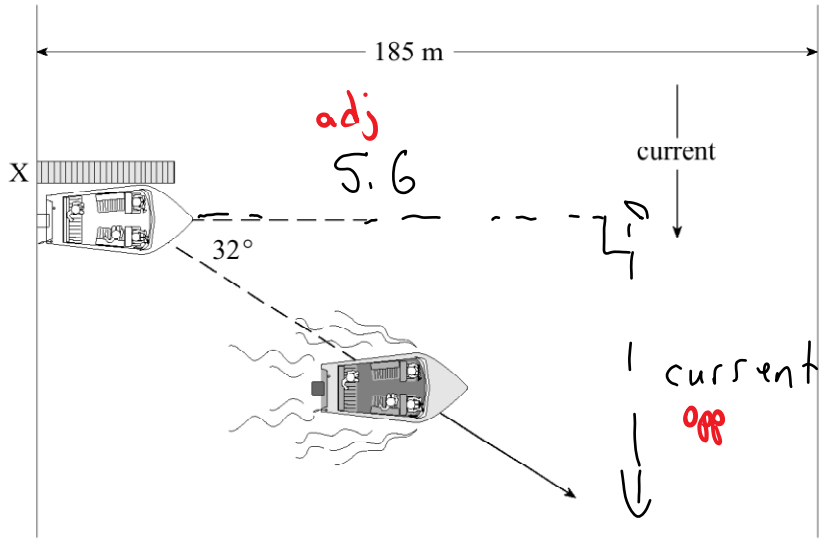
$v_f = v_i + at$

$t = \frac{v_f - v_i}{a} = 4.6$

13.

A boat which can travel at 5.6 m/s in still water heads due east across a river from a dock at **X**. The boat's resultant path is 32° south of east.

N
W E
S



$\tan 32 = \frac{\text{current}}{5.6}$

current $= 5.6 \times \tan 32$

a) What is the speed of the current? **(5 marks)**

current $= 5.6 \times \tan 32 = 3.5$ m/s

b) How long will it take the boat to reach the far shore if the river is 185 m wide? **(2 marks)**

$d = v_i t + \frac{1}{2} a t^2$

$t = \frac{d}{v} = \frac{185}{5.6} = 33.0$ s

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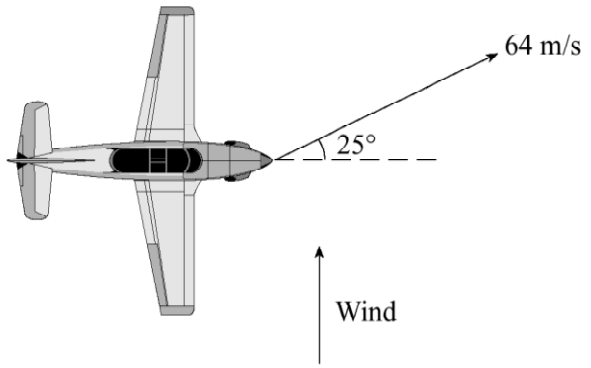
14.

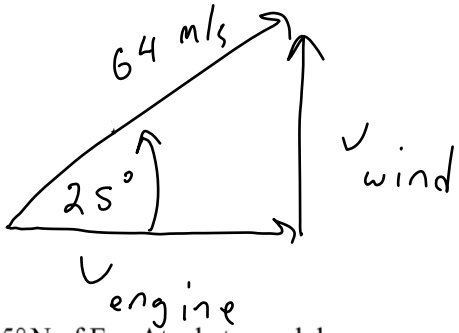
Which of the following remain(s) constant for a projectile: its horizontal velocity component, v_H, its vertical velocity component, v_V, its vertical acceleration, g?

A. v_V
B. g and v_V
C. g and v_H
D. g, v_H and v_V

15.

A pilot points an aircraft due east, while the wind blows from the south.





The resultant velocity of the aircraft over the ground is 64 m/s, 25° N of E . At what speed does the wind blow?

A. 2.6 m/s
B. 27 m/s
C. 30 m/s
D. 58 m/s

$\sin 25° = \frac{v_{wind}}{64} \rightarrow v_w = 64 \sin 25°$

16. A soccer ball is kicked over level ground with an initial velocity of 18 m/s, 24° above the horizontal.

a) How long does it take the ball to return to the ground? **(4 marks)**

b) What is the range of the ball? **(3 marks)**

a) $v_{y_i} = 18 \sin 24 = 7.32$ m/s $\quad a_y = -9.8$ m/s^2

$v_{y_f} = -7.32$ m/s $\quad t = ?$

$t = \frac{v_f - v_i}{a} = \frac{-7.32 - 7.32}{-9.8} = 1.5$ s

b) $d_x = v_x t = (18 \cos 24)(1.5) = 24.7$ m

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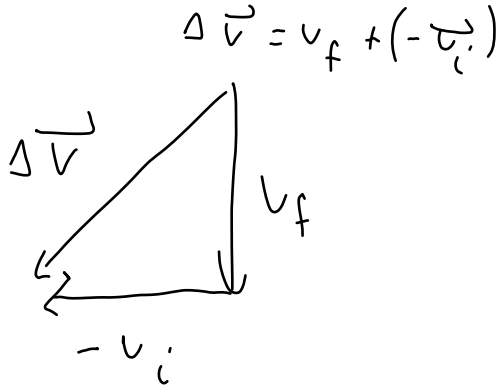
17.

An airplane which was flying eastward is later flying southward at the same speed. Which vector shows the airplane's **change** in velocity?

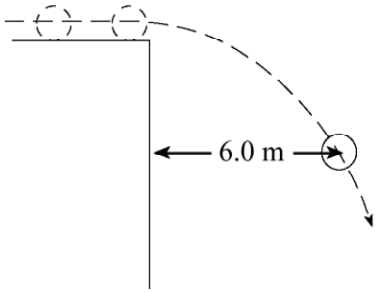
A. B.

C. D.



18.

At $t = 0$ s a ball rolls off the edge of a vertical cliff. At $t = 2.0$ s the ball is 6.0 m from the cliff as shown.



$v_x = ?$ $d_x = 6$ when $t = 2$

$v_x = \frac{d_x}{t} = \frac{6}{2} = 3.0$ m/s

$d_x = v_x t = 3(4) = 12$ m

How far is the ball from the cliff at $t = 4.0$ s?

A. 6.0 m
B. 9.0 m
C. 12 m
D. 24 m

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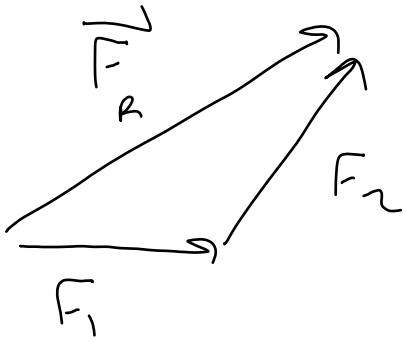
19.

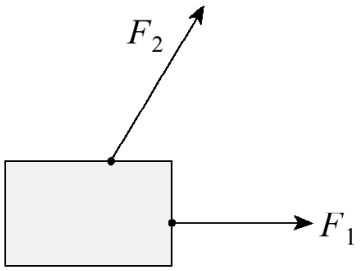
Which of the following statements concerning vector and scalar quantities is **incorrect**?

A. All scalar quantities have direction.
B. All vector quantities have direction.
C. All scalar quantities have magnitude.
D. All vector quantities have magnitude.

20.

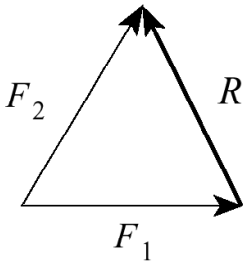
Two forces act on an object as shown in the diagram.



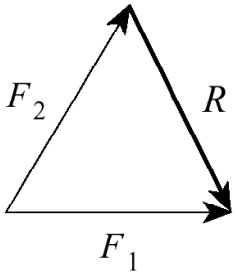


Which of the following **best** shows the resultant R of these forces?

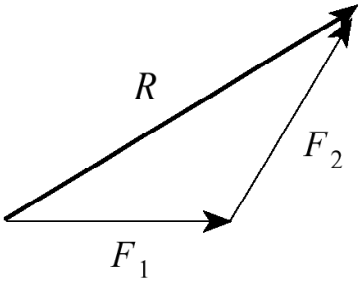
A.



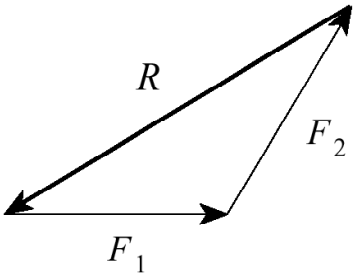
B.



C.



D.



21. Starting from rest, a jet takes 25 s and needs 1 500 m of runway to become airborne. What is its speed ~~when it leaves~~ the ground?

A. 60 m/s B. 120 m/s C. 250 m/s D. 1500 m/s

$d = 1500 \quad t = 25 \quad v_i = 0 \quad v_f = ? \quad$ need a

$d = v_i t + \frac{1}{2} a t^2$

$a = \dfrac{d - v_i t}{\frac{1}{2} t^2}$

$a = \dfrac{1500}{\frac{1}{2}(25)^2} = 4.8 \ m/s^2$

$v_f = v_i + at$

$= 0 + (4.8)(25) = 120 \ m/s$

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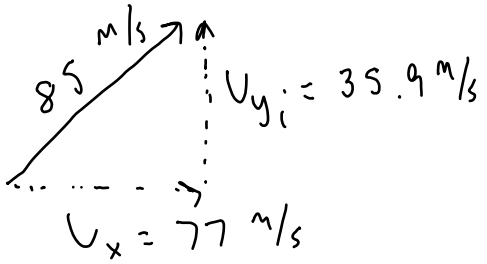
22. A projectile is launched over level ground at 85 m/s, 25° above the horizontal. Ignore air resistance.

a) Calculate the range of the projectile. **(5 marks)**



$v_{y_i} = 35.9$

$v_{y_f} = -35.9$

$a_y = -9.8$

$$t = \frac{v_f - v_i}{a} = \frac{-35.9 - 35.9}{-9.8}$$

$$t = 7.32 \text{ s}$$

$$d_x = v_x t = (77)(7.32) = 5.6 \times 10^2 \text{ m}$$

b) Using principles of physics, comment on the horizontal and vertical components of the projectile's velocity and acceleration during the flight. **(4 marks)**

Velocity	Acceleration
Horizontal: constant	Horizontal: 0 m/s^2
Vertical: changing	Vertical: constant (-9.8 m/s^2)

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23.

When a 2.0 kg rock is dropped from a cliff it hits the beach at 24 m/s. At what speed would a 4.0 kg rock, dropped from the same cliff, hit the beach? Ignore friction.

A. 12 m/s
B. 24 m/s
C. 34 m/s
D. 48 m/s

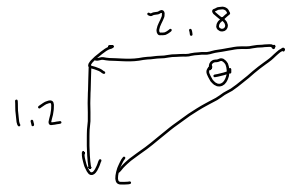
same speed, since mass is irrelevant

24.

Pamela swims at 2.8 m/s relative to the water, heading west. The current flows south at 1.2 m/s. Find Pamela's resultant direction.

N
W E
S

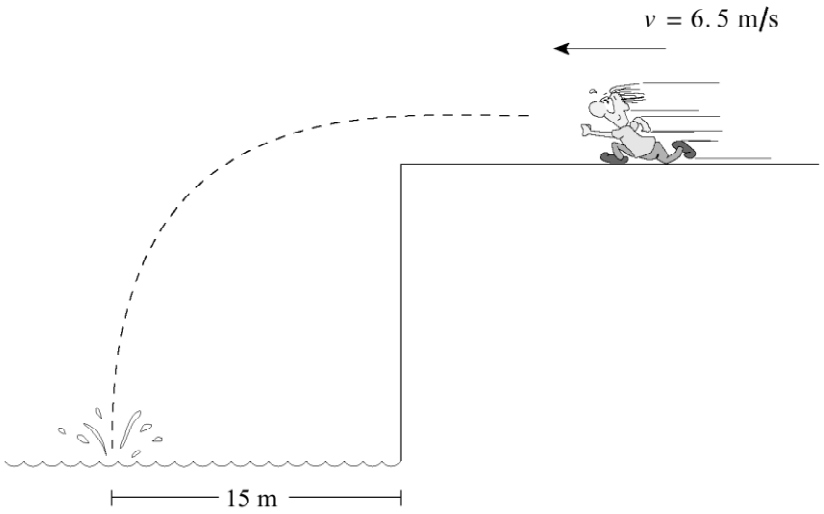
A. 23° S of W
B. 25° S of W
C. 23° N of W
D. 25° N of W



$\theta = \tan^{-1}\left(\frac{1.2}{2.8}\right)$

25.

Mike runs horizontally off a cliff at 6.5 m/s and lands in the water 15 m from the base of the cliff.



a) How long does it take Mike to hit the water? **(3 marks)**

$d_x = v_x t + \frac{1}{2} a_x t^2$

$t = \frac{d_x}{v_x} = \frac{15}{6.5} = 2.31 \text{ s}$

b) How high is the cliff? **(4 marks)**

$t = 2.31\ s \qquad v_{y_i} = 0 \qquad a_y = -9.8\ m/s^2$

$d_y = v_y t + \frac{1}{2} a_y t^2$

$d_y = \frac{1}{2}(-9.8)(2.31)^2 = 26.1\ m$

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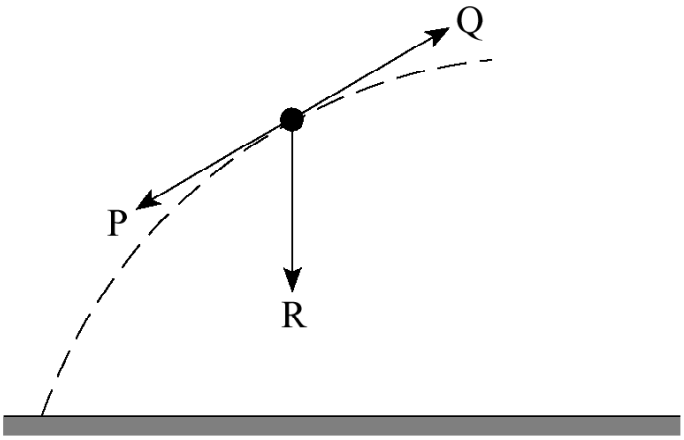
26.

The projectile shown below has an acceleration which is



A. zero.
B. in the direction of P.
C. in the direction of Q.
D. in the direction of R.

only F_g is acting on projectile

27.

An object is launched at 65° to the horizontal with an initial speed of 25 m/s. What is the maximum height reached by this object?

A. 5.7 m
B. 26 m
C. 32 m
D. 150 m

$v_{y_i} = 25 \sin 65 = 22.66$

$v_{y_f} = 0$

$a_y = -9.8$

$d = \frac{v_f^2 - v_i^2}{2a} = 26.2 \text{ m}$

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28.

A ball is kicked into the air from the surface of a playing field. If friction is negligible, the ball will follow a path that is

A. circular.
B. elliptical.
C. parabolic.
D. hyperbolic.

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29.

A rock is thrown from ground level at 18 m/s, 25° above horizontal. What are the vertical and horizontal components of its launch velocity?

$v_y = 18 \sin 25$

$v_x = 18 \cos 25$

	VERTICAL COMPONENT	HORIZONTAL COMPONENT
A.	16 m/s ✗	7.6 m/s ✗
B.	7.6 m/s ✓	16 m/s ✓
C.	20 m/s ✗	9.3 m/s ✗
D.	9.3 m/s ✗	20 m/s ✓

30

A motorcycle accelerates uniformly from 12 m/s to 30 m/s while travelling 420 m. Its acceleration is

$a = \frac{v_f^2 - v_i^2}{2d} = \frac{30^2 - 12^2}{2(420)} =$

A. 0.043 m/s^2
B. 0.050 m/s^2
C. 0.10 m/s^2
D. 0.90 m/s^2

9808

31.

A rock is thrown from a clifftop at 18 m/s, 25° above the horizontal. It lands on the beach 4.2 s later.

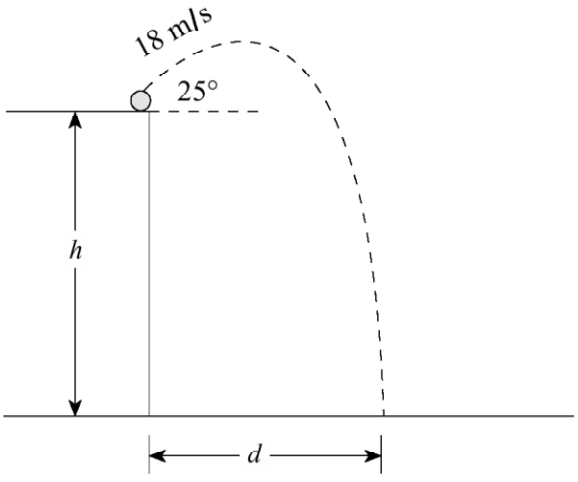
a) $t = 4.2$

$v_{y_i} = 7.61$ m/s

$a_y = -9.8$

$d_y = v_{y_i} t + \frac{1}{2} a t^2$

$d_y = 54.5$ m



a) What is the height h of the cliff? **(4 marks)**

b) How far from the base of the cliff d did the rock land? **(3 marks)**

$d_x = v_x t = (18 \cos 25)(4.2) = 68.5$ m

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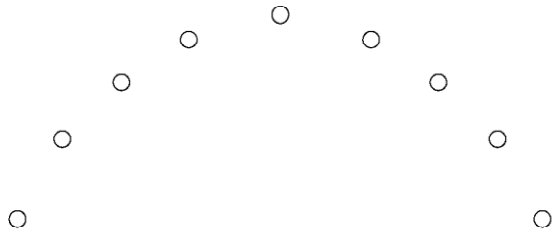
9901
32.

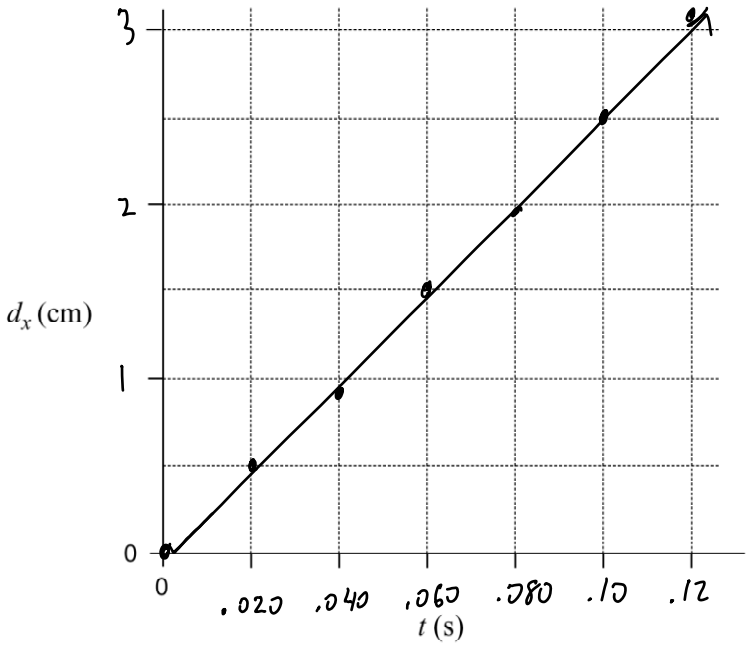
A student collects data from the path of a projectile similar to that shown in the diagram.



The student records the following data for horizontal displacement from the initial launch position as a function of time.

d_x (cm)	0.0	0.5	0.9	1.5	1.9	2.5	3.1
t (s)	0.000	0.020	0.040	0.060	0.080	0.100	0.120

a) Plot a graph of d_x vs. t on the graph below. **(2 marks)**



b) Calculate the slope of the line, giving your answer in appropriate units. **(2 marks)**

$m = \frac{2.5 - 0}{.1 - 0} = 25 \text{ cm/s}$

c) Based on this data and this graph, make a statement about projectiles. **(1 mark)**

slope is constant

$\therefore v_x$ is constant, since $v_x = \frac{d_x}{t}$

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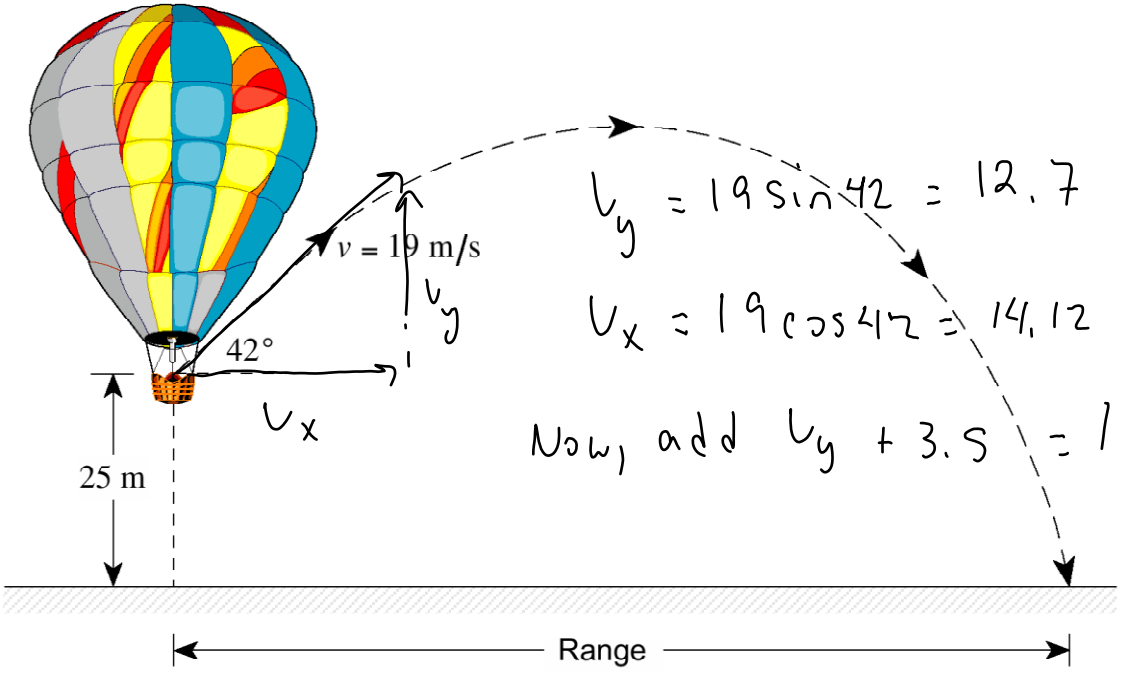
33. Scholarship question: A 0.50 kg ball is thrown at 42° above the horizontal at 19 m/s from the hot air balloon when the balloon is 25 m above the ground. **The balloon is traveling upwards at a constant velocity of 3.5 m/s**.



What is the range? **(10 marks)**

$v_{y_i} = 16.2$ m/s $a_y = -9.8$

$d_y = -25$ m need time!

$d_y = v_y t + \frac{1}{2} a t^2$

$4.9t^2 - 16.2t - 25 = 0$ use quadratic formula

$t = 4.45$ s

$d_x = v_x t = (14.12)(4.45) = 62.8$ m

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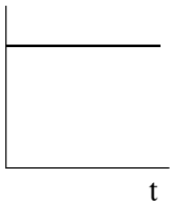
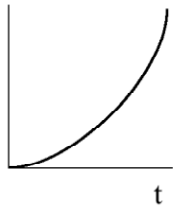
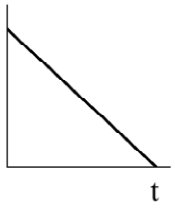
0006
34.

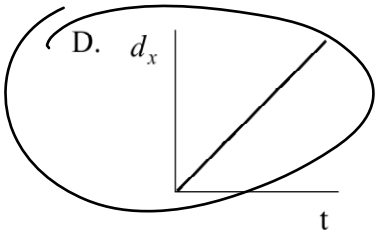
Which of the following graphs best illustrates the horizontal displacement of a projectile as a function of time? Ignore friction.

A. 

B. 

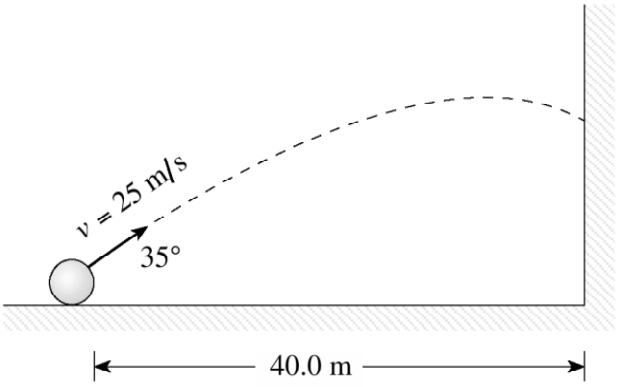
slope is v_x which is constant

C. 

D. 

0206
35.

A projectile is launched towards a wall as shown in the diagram below.



need v_{y_f}

$v_{y_i} = 14.34$ m/s

$a_y = -9.8$ m/s^2

$t = ?$

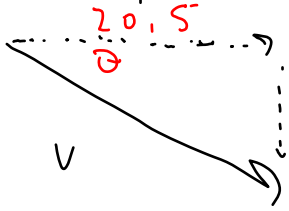
$\theta = \tan^{-1}\left(\frac{4.8}{20.5}\right)$

With what velocity (magnitude and direction) does the projectile hit the wall? **(7 marks)**

need time

$d_x = v_x t \rightarrow t = \frac{d_x}{v_x} = \frac{40}{25\cos(35°)} = 1.95$ s

$v_{y_f} = v_{y_i} + a t = 14.34 + (-9.8)(1.95) = -4.8$ m/s



$\vec{v} = 21$ m/s @ 13° below horizontal

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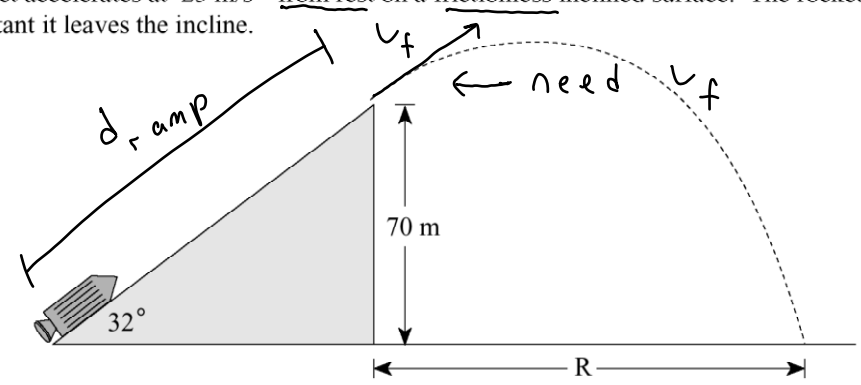
36. Scholarship question!

1. A rocket accelerates at 25 m/s^2 from rest on a frictionless inclined surface. The rocket stops firing at the instant it leaves the incline.



$d_{ramp} = \frac{70}{\sin 32} = 132.1$ m

$a = 25$

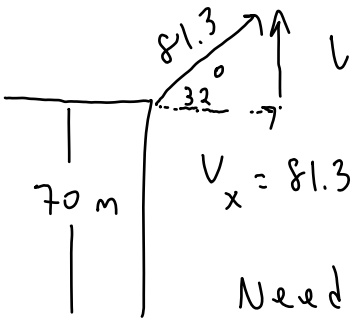
$v_0 = 0$

$v_f = ?$

If air resistance is negligible, what is the distance R to the point of impact? **(12 marks)**

$v_f^2 = v_i^2 + 2ad$

$v_f = \sqrt{0 + 2(25)(132.1)} = 81.3$ m/s



$v_{y_i} = 81.3 \sin 32 = 43.1$

$v_x = 81.3 \cos 32 = 68.92$

Need time of flight : solve vertically

$d_y = v_{y_i} t + \frac{1}{2} a t^2$

$-70 = 43.1 t - 4.9 t^2$

$4.9 t^2 - 43.1 t - 70 = 0$ use quad. form.

$t = 10.2$, ~~-1.4~~

Now, $d_x = v_x t + \frac{1}{2} a_x t^2$

$d_x = (68.92)(10.2) = 703$ m

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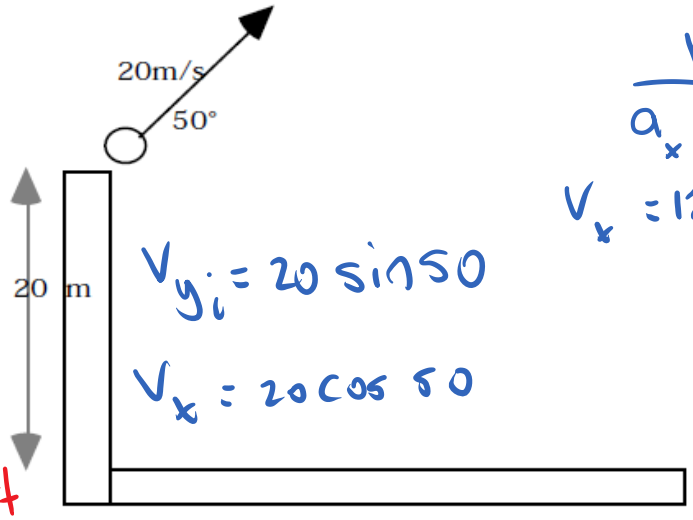
37. Find the range of the following projectile: **(7 marks)**



$V_{y_i} = 20 \sin 50$

$V_x = 20 \cos 50$

H	V
$a_x = 0$	$a_y = -9.8$
$V_x = 12.856$	$V_{y_i} = 15.321$
	$d_y = -20$

Vert

find v_{y_f} ! $v_{y_f} = \sqrt{v_{y_i}^2 + 2 a_y d_y}$

$v_{y_f} = \sqrt{15.321^2 + 2(-9.8)(-20)} = 25.035 \text{ m/s} = -25.035 \text{ m/s}$

down, so negative!

$t = \frac{v_{f_y} - v_{i_y}}{a_y} = \frac{-25.035 - 15.321}{-9.8} = 4.1179 \text{ s}$

Hori:

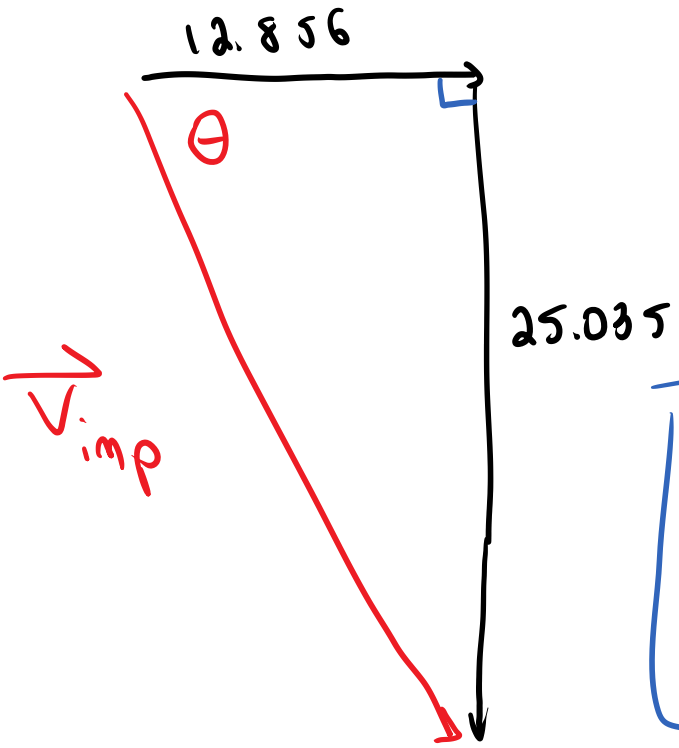
$d_x = v_x t = (12.856)(4.1179) = \boxed{52.9 \text{ m}}$

38. Find the impact velocity for the previous question. **(7 marks)**

from previous question...

$V_x = 12.856$ and $V_{y_f} = -25.035$

Now, draw vector Δ



$V_{imp}^2 = 12.856^2 + 25.035^2$

$V_{imp} = 28.1$ m/s @ 62.8° below the horizontal

$\tan\theta = \frac{25.035}{12.856}$

$\theta = \tan^{-1}\left(\frac{25.035}{12.856}\right)$

$\theta = 62.8°$

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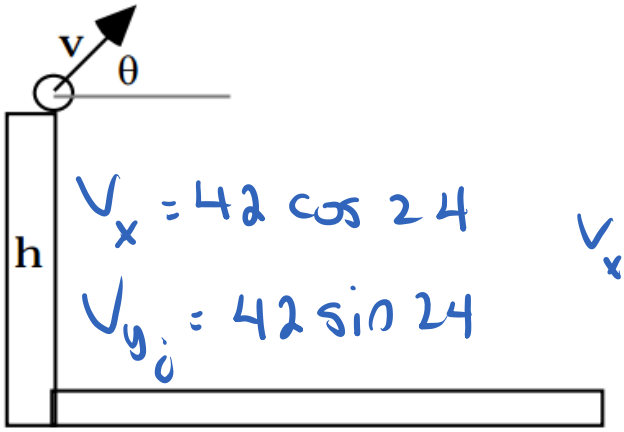
39. Find the range of the following, if v = 42 m/s, θ=24°, and h= 56 m. **(7 marks)**



$V_x = 42 \cos 24$

$V_{y_i} = 42 \sin 24$

H	V
$a_x = 0$	$a_y = -9.8$
$V_x = 38.369$	$V_{y_i} = 17.083$
	$d_y = -56$

Vert

Find V_{y_f}! $V_{y_f} = \sqrt{V_i^2 + 2ad}$

$V_{y_f} = \sqrt{17.083^2 + 2(-9.8)(-56)} = -37.275$ m/s

downward, so negative!

$t = \frac{V_{y_f} - V_{y_i}}{a_y} = \frac{-37.275 - 17.083}{-9.8} = 5.5467$ s

Hori

$d_x = V_x t = (38.369)(5.5467) = \boxed{213 \text{ m}}$

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Answers:

1. d
2. a
3. a) 3.18 m b) 16.2 m/s
4. c
5. a
6. b
7.
   - The horizontal velocity component is constant. **1 mark**
   - The vertical velocity component constantly changes. **1 mark**
   - This vertical acceleration is caused by the force of gravity. **1 mark**
   - The downward direction of the change in velocity / acceleration / force must be mentioned. **1 mark**
8. b
9. a) 2.9 s b) 34 m/s @ 18° below the horizontal
10. c
11. d
12. b
13. a) 3.5 m/s b) 33 s
14. c
15. b
16. a) t= 1.49 s b) 25 m
17. d
18. c
19. a
20. c
21. b
22. a) 5.6×10^2 m
    b)
    The horizontal component of velocity remains constant. There is no horizontal acceleration (assuming air resistance is negligible). ← **2 marks**

    The vertical component of velocity changes continuously during the flight. ← **1 mark**

    The vertical acceleration is constant at 9.8 m/s², downward, throughout the flight. ← **1 mark**
23. b
24. a
25. a) 2.3 s b) 26 m
26. d
27. b
28. c
29. b
30. d
31. a) h=54 m b) range = 69 m
32. b) 25 cm/s. The slope is horizontal velocity
    c) Since the slope is constant, the horizontal velocity of projectiles is constant
33. 62.8 m
34. d
35. 21 m/s @13° below the horizontal
36. v=703 m
37. d= 52.9 m
38. v= 28.1 m/s @ 62.8º below the horizontal
39. d = 213 m