Exam 01: Chapters 01—03

1. You are *adding* these numbers: 3.1415 + 4.77. The correct answer will have
   $3.1415 + 4.77 = 7.91$
   A) one decimal place.
   B) one significant digit.
   C) two decimal places.
   D) two significant digits.
   E) three decimal places.

2. You are *multiplying* these numbers: (8.81)·(9.014). The correct answer will have
   $8.81 \cdot 9.014 = 79.4$
   A) one decimal place.
   B) one significant digit.
   C) two decimal places.
   D) two significant digits.
   E) three decimal places.

3. Sample equation: $v = v_0 + 2at$
   A) You cannot tell if the equation is correct or not because you do not know the units on the (2).
   B) This equation is both dimensionally and physically correct.
   C) This equation is neither dimensionally nor physically correct.
   D) This equation is dimensionally incorrect, but physically correct.
   E) This equation is dimensionally correct, but physically incorrect.

4. Compare dimensional vs physical correctness.
   A) An equation that is dimensionally incorrect may still be physically correct.
   B) An equation that is physically correct may still be dimensionally incorrect.
   C) An equation that is dimensionally correct is also physically correct.
   D) An equation that is physically correct is also dimensionally correct.
   E) All of the statements above are true.

For questions 5 through 9, identify each of the following as either A) a ***scalar*** quantity or B) a ***vector*** quantity.

5. **Speed**. 6. **Mass**. 7. Displacement. 8. Acceleration. 9. **Time**.

During an interval of **40 seconds**, an object travels from **x = 0** to **x = 10m**, then to **x = –20m**. Answer questions 10–12 numerically to the *nearest integer*. Include *sign* when appropriate.

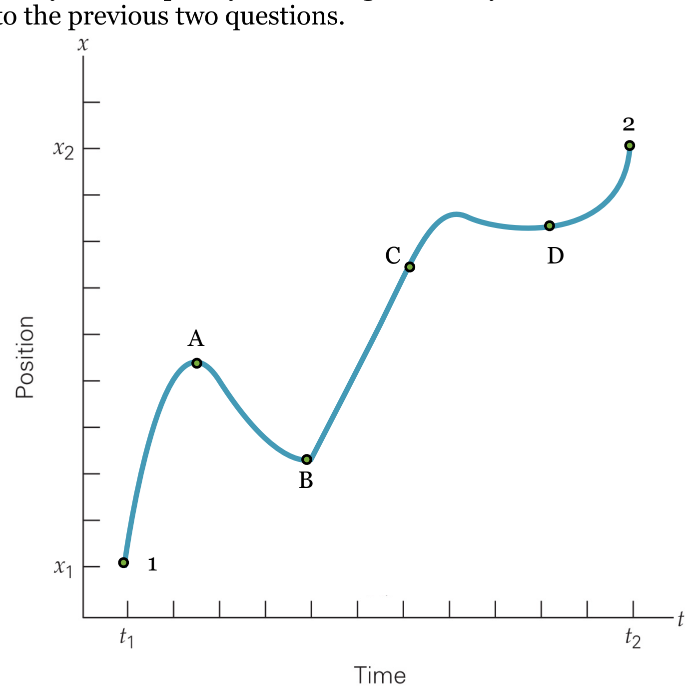
10. What is the *displacement* of this object?
    x = –20m

11. What is the *average speed* of this object?
    40m/40s = **1 m/s**

12. What is the *average velocity* of this object?
    –20m/40s = -0.5m/s

13. Distinguish between *average speed* and *average velocity*.
    A) There is no difference. The words speed and velocity are completely interchangeable; they are calculated exactly the same way, as shown in the answers to the previous two questions.
    B) An average speed is calculated using total elapsed distance per time. This is different than average velocity, which uses displacement per time.
    C) The average speed of an object is a vector, but average velocity is a scalar quantity.

Using the position as a function of time curve shown on the right, answer questions 14–16.

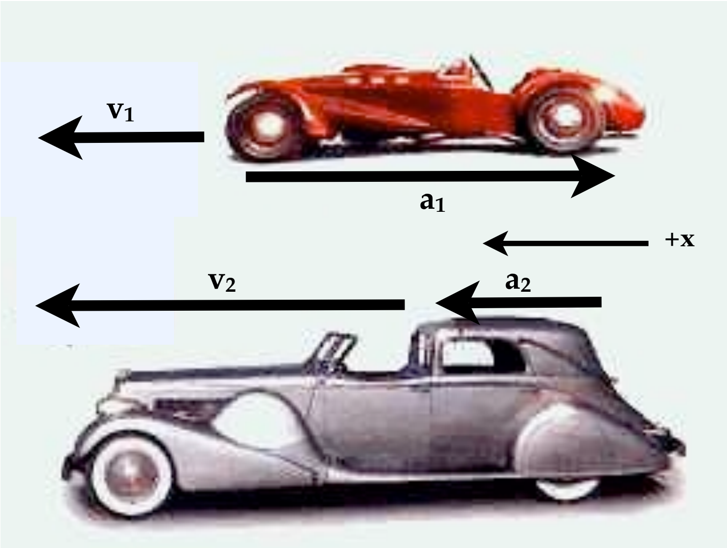


14. Where is the object's velocity *constant*?
    A) Nowhere. The instantaneous velocity of this object is changing continuously.
    B) From position 1 to A.
    C) from position A to B.
    D) From position B to C.
    E) From position D to 2.

15. Compare the *average velocity* for the interval **A to B** with the *average velocity* for the interval **C to D**.
    A) There is no way to compare the intervals without numerical values for the positions and times.
    B) The average velocity is the same over both intervals.
    C) The average velocity is positive from A to B and negative from C to D.
    D) The average velocity has a greater magnitude from C to D.
    E) The average velocity has a greater magnitude from A to B.

16. If each tick on the time axis represents one second, at what time does the object have the the *greatest instantaneous velocity*?
 A) 1.5 s. B) 2.5 s. C) 6 s. D) 9 s. E) 11 s.

17. Can the average velocity of an object ever *exceed* the average speed of an object?
 A) Certainly. When an object's displacement is greater than its distance, this is the result.
 B) No. It would not be possible for an object's displacement to exceed the distance it traveled.



Use the figure on the left to answer questions 18–20. Assume that the cars are shown at time **t = 0** and position **x = 0**. In this case, let the *positive direction be to the left*, the direction of the motion of the cars. Also assume that the acceleration vectors indicated remain constant.

18. True or **false**: Classic speedster (car 1) is speeding up.

19. True or **false**: Classic roadster (car 2) will eventually be passed by classic speedster (car 1).

20. **True** or false: At some time t in the future, classic speedster (car 1) will have a negative displacement.

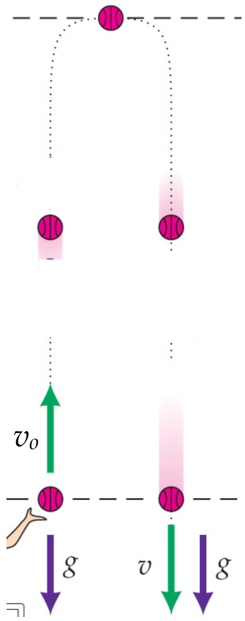
In a *new situation*, classic speedster (car 1) is at rest on a one mile (**1600m**) oval track. When the flag drops, the car covers one complete lap in a time of **45 seconds**. Answer questions 21–23.

21. True or **false**: The average velocity of car 1 was 36 m/s.

22. **True** or false: Even if car 1 maintained constant speed around the track, its acceleration was not zero.

23. **True** or false: Any object moving with constant velocity must have zero acceleration.

An object is thrown straight up in the air with an initial velocity $\mathbf{v}_o$. It is caught on the way back down at the same height from which it was thrown. Answer questions 24–27.



24. When the object is thrown straight up in the air,
 A) its velocity $\mathbf{v}_o$ and acceleration are both positive.
 B) its velocity $\mathbf{v}_o$ and acceleration are both negative.
 C) its velocity $\mathbf{v}_o$ is positive, but its acceleration is zero.
 D) its velocity $\mathbf{v}_o$ is positive, but its acceleration is negative.
 E) its velocity $\mathbf{v}_o$ is definitely positive, but its acceleration might be negative or positive.

25. As it rises, its instantaneous velocity **v**
 A) decreases while its acceleration increases.
 B) remains constant, and so does the acceleration.
 C) increases as the acceleration decreases.
 D) decreases while the acceleration remains constant.
 E) remains constant as the acceleration decreases.

26. At the top of its trajectory,
 A) neither velocity nor acceleration can be determined.
 B) its velocity and acceleration are both zero.
 C) its velocity is 9.8m/s and its acceleration is zero.
 D) its velocity is 9.8m/s and its acceleration is 9.8m/s^2.
 E) its velocity is zero and its acceleration is 9.8m/s^2.

27. **True** or false: The object will spend the same amount of time falling as it did rising.

28. An object is released from **rest** from exactly **1 m** above the floor. As it strikes the ground, its *velocity* is

$$v^2 = v_o^2 + 2ax$$

$$v = \sqrt{2\left(9.8\,\tfrac{\text{m}}{\text{s}^2}\right)(1\text{m})} = 4.4\,\tfrac{\text{m}}{\text{s}}$$

A) 0 m/s.
B) 1.0 m/s.
C) **4.4 m/s.**
D) 9.8 m/s.
E) 19.6 m/s.

29. An object is released from **rest** from exactly **2 m** above the floor. *How long* does it take to strike the ground?

$$x = v_o t + \tfrac{1}{2}at^2$$

$$1 = 0 + \tfrac{1}{2}\left(9.8\,\tfrac{\text{m}}{\text{s}^2}\right)t^2$$

$$t = 0.64\text{s}$$

A) 0 s.
B) 0.41 s.
C) **0.64 s.**
D) 2.0 s.
E) 4.9 s.

30. An object is released from **rest** from the top of a very tall building. *How far* does it fall in **3 seconds**?

$$y = v_o t + \tfrac{1}{2}at^2$$

$$y = 0 + \tfrac{1}{2}\left(9.8\,\tfrac{\text{m}}{\text{s}^2}\right)(3\text{s})^2$$

$$y = 44.1\text{m}$$

A) 3 m.
B) 9.8 m.
C) 14.7 m.
D) 29.4 m.
E) **44.1 m.**

31. Resolve the vector A = 55.0m, $\theta_A = 230°$ into cartesian components:

$$A_x = (55\text{m})\cos 230° = -35.4\text{m}$$

$$A_y = (55\text{m})\sin 230° = -42.1\text{m}$$

A) **A** = (−42.1m)**î** + (−35.4m)**ĵ**
B) **A** = (42.1m)**î** + (−35.4m)**ĵ**
C) **A** = (35.4m)**î** + (42.1m)**ĵ**
D) **A** = (−35.4m)**î** + (42.1m)**ĵ**
E) **A = (−35.4m)î + (−42.1m)ĵ**

32. Find the *magnitude* B of the vector **B** = (33m)**î** + (−42m)**ĵ**.

$$B = \sqrt{(33\text{m})^2 + (-42\text{m})^2} = 53\text{m}$$

33. Find the *direction* angle θ_C of the vector **C** = (−54m)**î** + (25m)**ĵ**.

$$\theta = \tan^{-1}\left(\frac{25}{-54}\right) = 155°$$

34. Add the vectors from the previous two questions: **B** + **C** = **R**. What are the magnitude and direction of R?

$$R_x = 33 - 54 = -21\text{m}$$

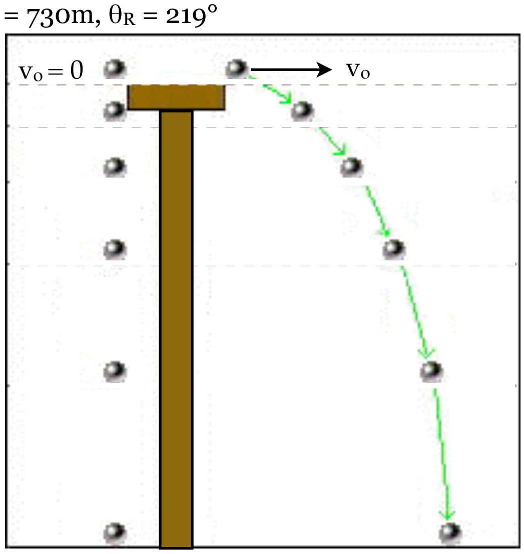
$$R_y = -42 + 25 = -17\text{m}$$

$$R = \sqrt{(-21\text{m})^2 + (-17\text{m})^2} = 27\text{m}$$

$$\theta = \tan^{-1}\left(\frac{-17}{-21}\right) = 219°$$

A) R = −38m, $\theta_R = 92°$
B) R = −38m, $\theta_R = 272°$
C) R = 27m, $\theta_R = 39°$
D) **R = 27m, $\theta_R = 219°$**
E) R = 730m, $\theta_R = 219°$

Two balls are released from the same height above the ground at exactly the same time. Ball A (on the left) is released from rest, while Ball B (on the right) is given an initial horizontal velocity. Answer questions 35–37.



35. After one second, which ball has fallen a greater vertical distance?
A) Ball A.
B) Ball B.
C) **Both balls have dropped the same vertical distance.**

36. Which ball strikes the ground first?
A) Ball A.
B) Ball B.
C) **Both balls strike at the same time.**

37. What would happen if you changed the horizontal launch velocity of the ball on the right (Ball B)?
    A) Increasing the launch speed will increase the amount of time Ball B spends in the air.
    B) Decreasing the launch speed will increase the amount of time Ball B spends in the air.
    C) Any change in the launch speed (either increase or decrease) will increase the time of flight of Ball B.
    D) Changing the launch speed (either increase or decrease) will have no effect on the time of flight of Ball B.

A projectile is launched from height $y_o = 0$, and lands at the same height ($y = 0$). The launch velocity $v_o = 15$m/s, at an angle of 35°. Assume that up is the +y direction, and answer questions 38–40.

38. At the very top of its trajectory, what is the (magnitude of the) velocity of the projectile?

$$v = v_{ox} = v_o \cos\theta$$

$$v = \left(15\,\tfrac{\text{m}}{\text{s}}\right)\cos 35° = 12.3\,\tfrac{\text{m}}{\text{s}}$$

    A) 0 m/s.
    B) 8.6 m/s
    C) 12.3 m/s
    D) 15 m/s
    E) 35 m/s

39. What is the acceleration vector at the top of the trajectory?
    A) **a** = (0m/s²)**î** + (9.8m/s²)**ĵ**.
    B) a = (0m/s²)î + (−9.8m/s²)ĵ.
    C) **a** = (9.8m/s²)**î** + (9.8m/s²)**ĵ**.
    D) **a** = (−9.8m/s²)**î** + (−9.8m/s²)**ĵ**.
    E) **a** = (9.8m/s²)**î** + (−9.8m/s²)**ĵ**.

40. The total time of flight for this projectile is 1.76 seconds. When is the projectile at its maximum height?
    A) t = 0s.
    B) t=0.88s.
    C) t = 1.33s.
    D) t = 1.76s.
    E) t = 3.51s.

Using the same launch speed ($v_o = 15$m/s), the projectile can be launched at different angles. Assume that up is the +y direction, and answer questions 41–43.

41. True or **false**: A launch at 35° will have the same horizontal range as a launch at 45°.

42. **True** or false: A launch at 50° will have a greater maximum height and range than a launch at 30°.

43. True or **false**: A launch at 40° will have a greater range and longer time of flight than a launch at 60°.

44. Calculate the horizontal component v_{ox} of a projectile launched at $\mathbf{v_o = 20}$ **m/s** at an angle of **40°**. Answer with three significant figures.

$$v_{ox} = v_o \cos\theta$$

$$v_{ox} = \left(20\,\tfrac{\text{m}}{\text{s}}\right)\cos 40° = 15.3\,\tfrac{\text{m}}{\text{s}}$$

45. This horizontal component of the launch velocity
    A) remains constant over the entire trajectory.
    B) increases continuously over the entire trajectory.
    C) decreases continuously over the entire trajectory.
    D) decreases as the ball rises, then increases as it falls.
    E) increases as the ball rises, then decreases as the ball falls.

46. Another projectile is launched with $\mathbf{v_o = 20}$**m/s** at **65°**. Determine vertical component of the velocity is v_{oy} and respond with two significant digits.

$$v_{oy} = v_o \sin\theta$$

$$v_{oy} = \left(20\,\tfrac{\text{m}}{\text{s}}\right)\sin 65° = 18.1\,\tfrac{\text{m}}{\text{s}}$$

47. This vertical component of the launch velocity
    A) remains constant over the entire trajectory.
    B) increases continuously over the entire trajectory.
    C) decreases continuously over the entire trajectory.
    D) increases as the ball rises, then decreases as it falls.
    E) decreases as the ball rises, then increases as the ball falls.

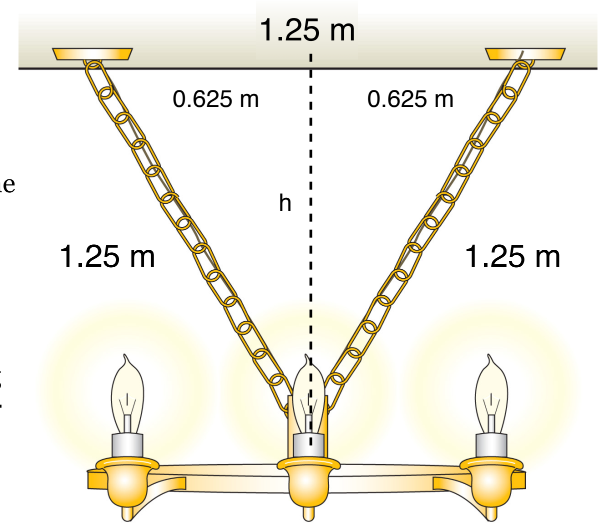
Two projectiles will be launched at the same angle, 30°. One projectile will have a greater launch speed: Projectile A will launch at 15 m/s, and Projectile B will launch at 25 m/s. Answer questions 48–50.

48. **True** or false: Projectile B will reach a greater maximum height than Projectile A.

49. True or **false**: Projectile A will have a greater horizontal range than Projectile B.

50. **True** or false: Projectile B will have a longer time of flight than Projectile A.

Problem 1



The chandelier shown on the left is supported by two chains, each **1.25m** in length. The chains are anchored to the ceiling, separated by **1.25m** as shown.

A) Determine the **vertical distance** from the chandelier to the ceiling.

$$(0.625\text{m})^2 + h^2 = (1.25\text{m})^2$$
$$h = 1.08\text{m}$$

B) If the decorator has specified that the chandelier *must* hang *precisely* **0.75m** from the ceiling, what should the **separation** of the chain anchors be?

$$\left(\frac{x}{2}\right)^2 + (0.75\text{m})^2 = (1.25\text{m})^2$$
$$x = 2.0\text{m}$$

Problem 2

A car is traveling on a long, straight highway with an initial velocity of **28.0 m/s**. The driver sees a wreck ahead, and hits the brakes (ignore any reaction time), slowing down at a uniform rate of **7.00m/s²**. After **two seconds**, the car hits an icy patch and the acceleration decreases to only **1.00 m/s²**. The car continues to move forward until it **stops**.

$$v_o = 28.0\,\tfrac{\text{m}}{\text{s}} \qquad a_2 = -1.00\,\tfrac{\text{m}}{\text{s}^2}$$
$$a_1 = -7.00\,\tfrac{\text{m}}{\text{s}^2} \qquad v_2 = 0\,\tfrac{\text{m}}{\text{s}}$$
$$t_1 = 2\text{s}$$

A) At t = 2.00sec, how fast is the car moving?

$$v_1 = v_o + a_1 t_1$$
$$v_1 = \left(28.0\,\tfrac{\text{m}}{\text{s}}\right) + \left(-7.00\,\tfrac{\text{m}}{\text{s}^2}\right)(2\text{s})$$
$$v_1 = 14\,\tfrac{\text{m}}{\text{s}}$$

B) At t = 2.00 sec, how far has the car traveled?

$$x_1 = v_o t_1 + \tfrac{1}{2} a_1 t_1^2$$
$$x_1 = \left(28.0\,\tfrac{\text{m}}{\text{s}}\right)(2\text{s}) + \tfrac{1}{2}\left(-7.00\,\tfrac{\text{m}}{\text{s}^2}\right)(2\text{s})^2$$
$$x_1 = 42\text{m}$$

C) How much total time elapses until the car stops?

$$v_2 = v_1 + a_2 t_2$$
$$0 = \left(14\,\tfrac{\text{m}}{\text{s}}\right) + \left(-1.00\,\tfrac{\text{m}}{\text{s}^2}\right) t_2$$
$$t_2 = 14\text{s}$$
$$t = t_1 + t_2 = 16\text{s}$$

D) How much total distance has the car traveled from the instant of initially applying the brakes?

$$v_2^2 = v_1^2 + 2a_2 x_2$$
$$0 = \left(14\,\tfrac{\text{m}}{\text{s}}\right)^2 + 2\left(-1.00\,\tfrac{\text{m}}{\text{s}^2}\right) x_2$$
$$x_2 = 98\text{m}$$
$$x = x_1 + x_2 = 140\text{m}$$

Problem 3

Shown on the left is a low-tech method for calculating your reaction time. Marcia holds a ruler level with the top of Wally's hand (thumb and fore-finger), and releases it from **rest**. Wally tries to grab the ruler as quickly as he can. When Wally grabs the ruler, it has fallen **15 cm** through his fingers.

$$v_o = 0\,\tfrac{\text{m}}{\text{s}}$$
$$a = 9.8\,\tfrac{\text{m}}{\text{s}^2}$$
$$y = 15\text{cm} = 0.15\text{m}$$

A) Determine the **elapsed time** from Marcia's release to Wally's grab (this is Wally's reaction time).

$$y = v_o t + \tfrac{1}{2}at^2$$
$$(0.15\text{m}) = 0 + \tfrac{1}{2}\left(9.8\,\tfrac{\text{m}}{\text{s}^2}\right)t^2$$
$$t = 0.175\text{s}$$

B) With what **speed** is the ruler moving when Wally grabs it?

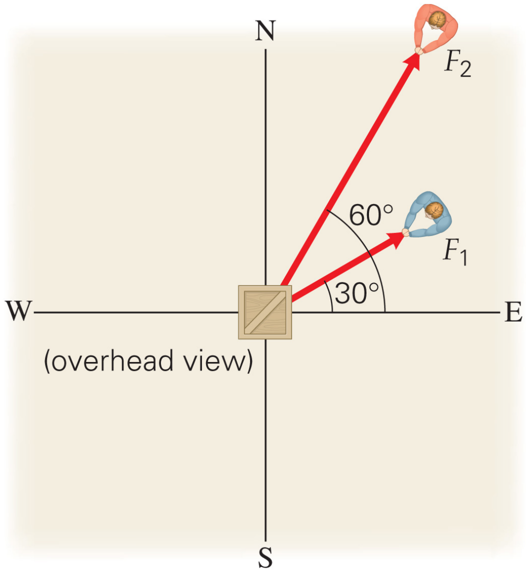
$$v^2 = v_o^2 + 2ay$$
$$v = \sqrt{2\left(9.8\,\tfrac{\text{m}}{\text{s}^2}\right)(0.15\text{m})} = 1.71\,\tfrac{\text{m}}{\text{s}}$$

C) Marcia now takes a tennis ball and throws it up with an initial velocity of **2.0m/s**. Can Wally grab the ball before it reaches its maximum height? Demonstrate your answer numerically.

$$v_o = +2.0\,\tfrac{\text{m}}{\text{s}} \qquad v = v_o + at$$
$$a = -9.8\,\tfrac{\text{m}}{\text{s}^2} \qquad 0 = \left(2.0\,\tfrac{\text{m}}{\text{s}}\right) + \left(-9.8\,\tfrac{\text{m}}{\text{s}^2}\right)t$$
$$v = 0 \qquad t = 0.204\text{s}$$

D) Assume that Wally does not grab the ball. How **high** above its starting point will the ball travel?

$$v^2 = v_o^2 + 2ay$$
$$0 = \left(2.0\,\tfrac{\text{m}}{\text{s}}\right)^2 + 2\left(-9.8\,\tfrac{\text{m}}{\text{s}^2}\right)y$$
$$y = 0.204\text{m}$$



Problem 4

Wally and Theodore are pulling the crate shown across the floor. Theodore applies **F_1 = 75N**, while Wally applies **F_2 = 150N**.

$$\vec{F}_1 = (F_1 \cos\theta_1)\hat{x} + (F_1 \sin\theta_1)\hat{y}$$
$$F_{1x} = (75\text{N})\cos 30° = 65\text{N}$$
$$F_{1y} = (75\text{N})\sin 30° = 37.5\text{N}$$
$$\vec{F}_2 = (F_1 \cos\theta_1)\hat{x} + (F_1 \sin\theta_1)\hat{y}$$
$$F_{2x} = (150\text{N})\cos 60° = 75\text{N}$$
$$F_{2y} = (150\text{N})\sin 60° = 130\text{N}$$

A) What is the **vector sum** of the two forces?

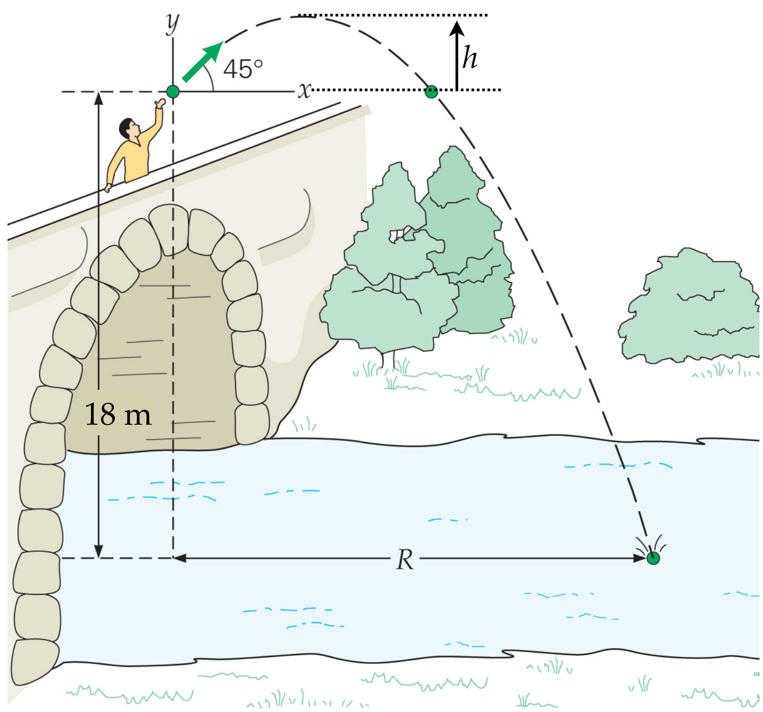
$$F_x = F_{1x} + F_{2x} = 140\text{N}$$
$$F_y = F_{1y} + F_{2y} = 168\text{N}$$
$$F = \sqrt{F_x^2 + F_y^2} = \sqrt{(140\text{N})^2 + (168\text{N})^2} = 219\text{N}$$
$$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right) = \tan^{-1}\left(\frac{168}{140}\right) = 50°$$

B) If Eddie tries to help by applying a third force **F_3 = 200N**, at what **angle** should he pull to create a **net force to the N** (+y direction)? This means that the sum of all three forces will have only a y–component, no x–component.

$$F_{3x} = -F_x = -140\text{N}$$
$$F_3^2 = F_{3x}^2 + F_{3y}^2$$
$$(200\text{N})^2 = (-140\text{N})^2 + F_{3y}^2$$
$$F_{3y} = 143\text{N}$$
$$\vec{F}_3 = (-140\text{N})\hat{x} + (143\text{N})\hat{y}$$
$$\theta_3 = \tan^{-1}\left(\frac{F_{3y}}{F_{3x}}\right) = \tan^{-1}\left(\frac{143}{-140}\right) = 134°$$

Problem 5

A stone is thrown from the bridge as shown. The initial velocity is $\mathbf{v_o}$ **= 15 m/s**, at a **45°** angle. The stone lands in the water, **18 m** below where it was released.



$$v_{ox} = v_o \cos\theta$$

$$v_{ox} = \left(15\,\tfrac{\text{m}}{\text{s}}\right)\cos 45° = 10.6\,\tfrac{\text{m}}{\text{s}} \rightarrow = +10.6\,\tfrac{\text{m}}{\text{s}}$$

$$v_{ox} = v_o \sin\theta$$

$$v_{oy} = \left(15\,\tfrac{\text{m}}{\text{s}}\right)\sin 45° = 10.6\,\tfrac{\text{m}}{\text{s}} \uparrow = +10.6\,\tfrac{\text{m}}{\text{s}}$$

$$a_x = 0\,\tfrac{\text{m}}{\text{s}^2}$$

$$a_y = 9.8\,\tfrac{\text{m}}{\text{s}^2} \downarrow = -9.8\,\tfrac{\text{m}}{\text{s}^2}$$

$$y_o = +18\text{m}$$

$$y = 0$$

A) How much **time** does the stone spend in the air?

$$y = y_o + v_{oy}t + \tfrac{1}{2}a_y t^2$$

$$0 = (+18\text{m}) + \left(+10.6\,\tfrac{\text{m}}{\text{s}}\right)t + \tfrac{1}{2}\left(-9.8\,\tfrac{\text{m}}{\text{s}^2}\right)t^2$$

$$4.9t^2 - 10.6t - 18 = 0$$

$$t = \frac{-10.6 \pm \sqrt{(-10.6)^2 - 4(4.9)(-18)}}{2(4.9)} = 3.28\text{s}$$

B) What is the **maximum height** h of the stone above the point where it was released?

$$v_y^2 = v_{oy}^2 + 2a_y h$$

$$0 = \left[\left(15\,\tfrac{\text{m}}{\text{s}}\right)\sin 45°\right]^2 + 2\left(-9.8\,\tfrac{\text{m}}{\text{s}^2}\right)h$$

$$h = 5.74\text{m}$$

C) Determine the horizontal **range** R of the stone.

$$x = v_{ox}t$$

$$R = \left(15\,\tfrac{\text{m}}{\text{s}}\right)\cos 45°(3.28\text{s}) = 34.8\text{m}$$