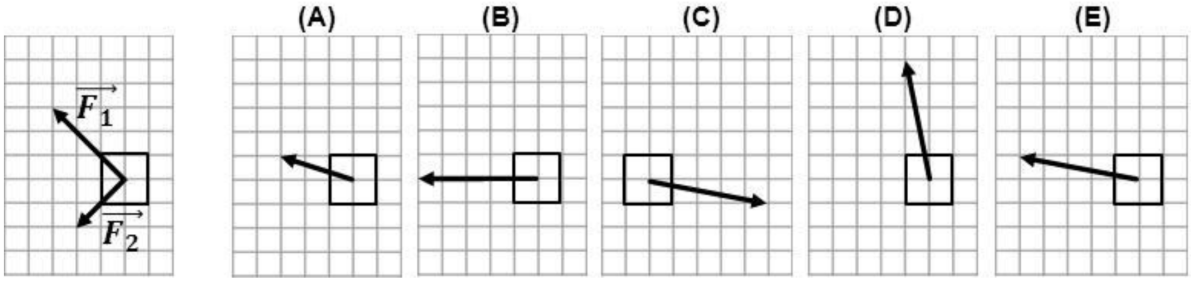
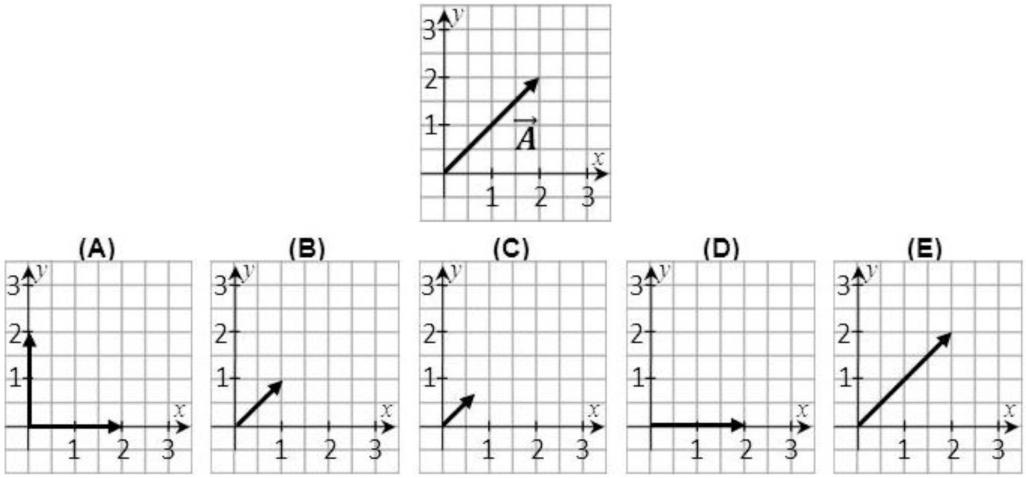
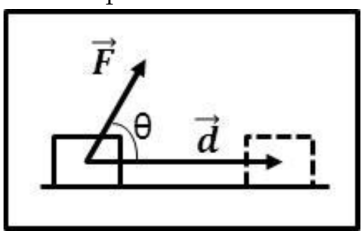
1. The figure shows a box (seen from above). Two forces, $\vec{F}_1$ and $\vec{F}_2$, act on the box. Choose the option that shows the net force $\vec{F}_1 + \vec{F}_2$ on this box.



2. The figure below shows vector $\vec{A}$. Choose the option that shows the unit vector in the direction of vector $\vec{A}$.



3. The figure shows a force $\vec{F}$ excerted on a box. The box moves a displacement $\vec{d}$. $\vec{F}$ and $\vec{d}$ form an angle θ. $|\vec{F}|$ is the magnitude og the force $\vec{F}$ and $|\vec{d}|$ is the magnitude of the displacement $\vec{d}$. Which option is the work done by the force $\vec{F}$, defining this work as the dot product $W = \vec{F} \cdot \vec{d}$?

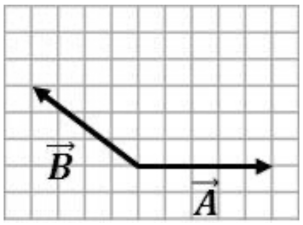


(A) $|\vec{F}||\vec{d}|$
(B) $|\vec{F}||\vec{d}|\cos\theta$
(C) $|\vec{F}|\cos\theta + |\vec{d}|\cos\theta$
(D) $|\vec{F}||\vec{d}|\sin\theta$
(E) $|\vec{F}|\cos\theta|\vec{d}|\sin\theta$

4. The velocity of an object is $\vec{v} = (4\text{ m/s})\hat{i} + (3\text{ m/s})\hat{j}$. We denote the unit vector in the direction of the velocity as $\hat{v}$. We can write the velocity vector as $\vec{v} = v\hat{v}$. Which option is the factor v?

(A) 5
(B) 5 m/s
(C) 7
(D) $(1\text{ m/s})\hat{i} + (1\text{ m/s})\hat{j}$
(E) $4\hat{i} + 3\hat{j}$

5. The figure below shows vectors $\vec{A}$ and $\vec{B}$ that have the same magnitude. Which of the following statements about the magnitude of the vector sum of these two vectors is true?

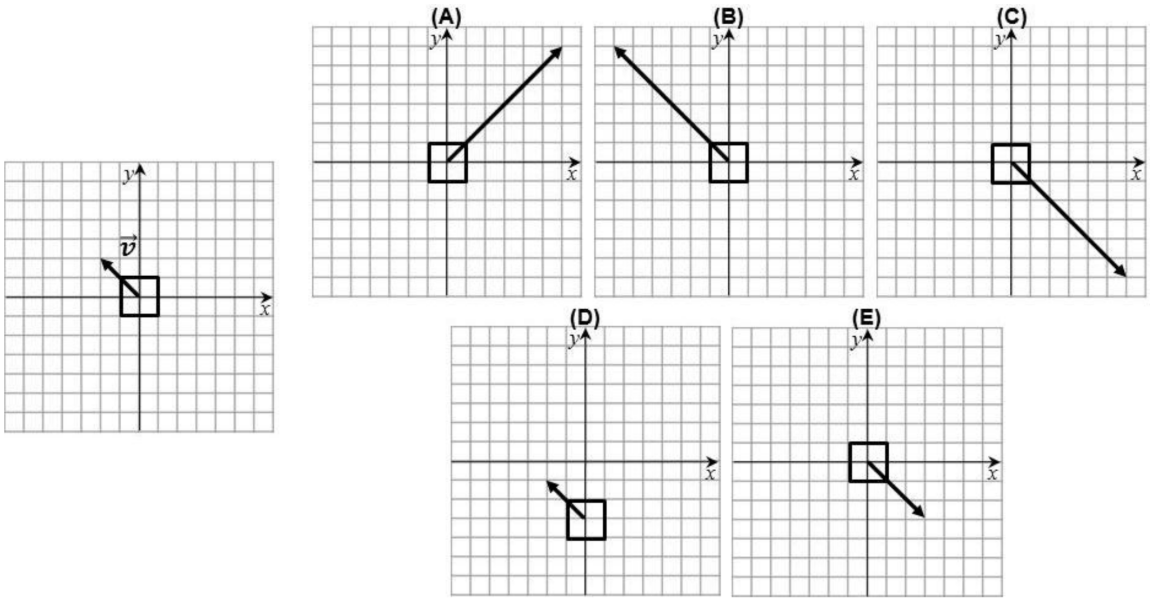


(A) The magnitude of the vector sum is greater than the magnitude of vector $\vec{A}$, and it is demonstrated by the direct application of the Pythagorean theorem.
(B) The magnitude of the vector sum is smaller than the magnitude of vector $\vec{A}$, because if we do the graphical addition of the two vectors we note that the vector sum is smaller.
(C) The magnitude of the vector sum is greater than the magnitude of vector $\vec{A}$, because the addition of two vectors always gives a resultant vector with greater magnitude than the vectors that are added up.
(D) The magnitude of the vector sum is equal to the magnitude of vector $\vec{A}$, and it is demonstrated by the direct application of the Pythagorean theorem.
(E) The magnitude of the vector sum is greater than the magnitude of vector $\vec{A}$, because the distance between the tips of the arrows is longer than the magnitude of vector $\vec{A}$.

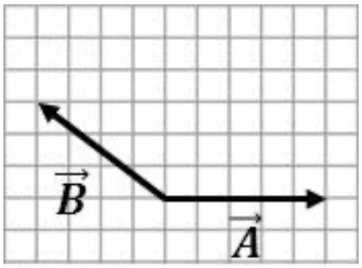
6. Consider the vector $\vec{A} = 1\hat{i} + 3\hat{j}$ and $\vec{B} = 5\hat{i}$. Which option is the dot product $(\vec{A} \cdot \vec{B})$?
(A) 5
(B) $-15\hat{k}$
(C) $5\hat{i} + 3\hat{j}$
(D) $6\hat{i} + 3\hat{j}$
(E) $5\hat{i}$

7. Vectors $\vec{A}$ and $\vec{B}$ point in the same direction. Choose the option that is true if and only if the two vectors are parallel.
(A) The vectors have the same magnitude.
(B) The vectors have at least one scalar component that is the same.
(C) All scalar components of the vectors are the same.
(D) The dot product of the vectors is zero.
(E) The cross product of the vectors is zero.

8. The figure below shows a box (seen from above) that moves at velocity $\vec{v}$. Choose the option that shows this box moving at velocity $-3\vec{v}$.

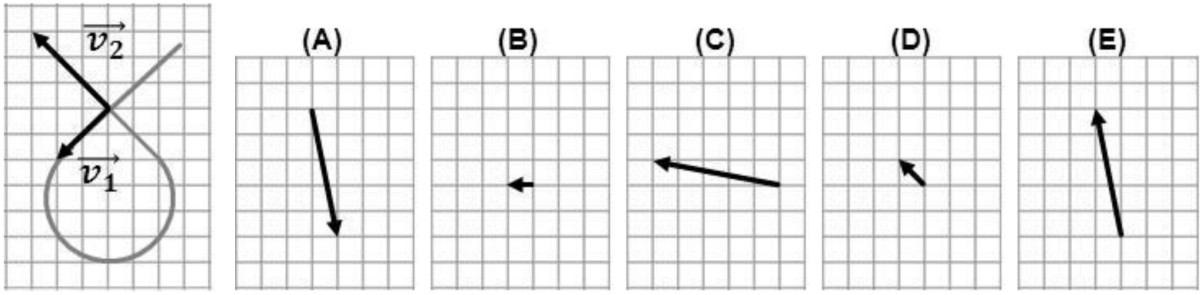


9. The figure below shows vectors $\vec{A}$ and $\vec{B}$. Which option is true for the dot product $(\vec{A} \cdot \vec{B})$?

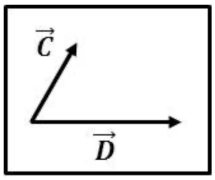


(A) The dot product is positive.
(B) The dot product is zero.
(C) The dot product is negative.
(D) Not enough information is given for deducing the sign of the dot product.
(E) The dot product of these vectors is not defined.

10. Consider a car (seen from above) that follows the path shown in the figure. The figure also shows the velocity of this car in two instants $\vec{v}_1$ and $\vec{v}_2$. Choose the option that shows the change of velocity vector that is the vector difference $\vec{v}_2 - \vec{v}_1$.

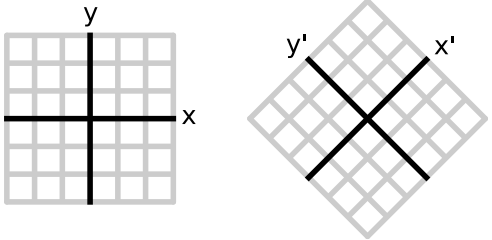


11. The figure below shows vectors $\vec{C}$ and $\vec{D}$. Which option is the best interpretation of the dot product $(\vec{C} \cdot \vec{D})$?



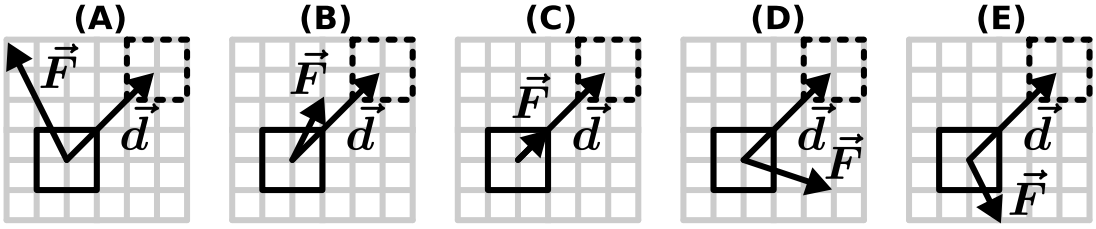
(A) The magnitude of a vector between $\vec{C}$ and $\vec{D}$ pointing up to the right.
(B) The projection of vector $\vec{C}$ onto vector $\vec{D}$ multiplied by the magnitude of vector $\vec{D}$.
(C) A vector between $\vec{C}$ and $\vec{D}$ pointing up to the right.
(D) A vector perpendicular to both vectors.
(E) A vector in the direction of $\vec{D}$.

12. The figure below shows a coordinate system xy, where the velocity of an object is $\vec{v} = (1\text{ m/s})\hat{i} + (-2\text{ m/s})\hat{j}$. The same situation is represented also in another coordinate system $x'y'$ that has bee rotated 45° with respect to xy. Choose the option that is true for the scalar components $v_{x'}$ ja $v_{y'}$.

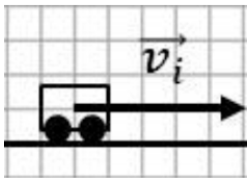


(A) $v_{x'} > 0$ m/s ja $v_{y'} > 0$ m/s
(B) $v_{x'} < 0$ m/s ja $v_{y'} > 0$ m/s
(C) $v_{x'} > 0$ m/s ja $v_{y'} < 0$ m/s
(D) $v_{x'} < 0$ m/s ja $v_{y'} < 0$ m/s
(E) One of the components is exactly zero.

13. The figure below shows a box (seen from above). The box moves a displacement $\vec{d}$. Several forces act on the box, and $\vec{F}$ is one of them. Choose the option for which the work done by this force, $W = \vec{F} \cdot \vec{d}$, is the greatest.



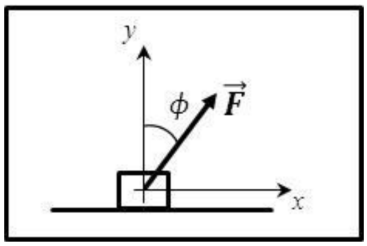
14. The figure below shows a cart moving at velocity $\vec{v}_i$. The mass of the cart is $m = 2$ kg. We wish to draw the momentum $\vec{p} = m\vec{v}_i$ as an arrow in the same figure. Choose the option that best describes how it should be drawn.



(A) It should be an arrow to the right with a length of 2 squares.
(B) It should be an arrow to the right with a length of 5 squares.
(C) It should be an arrow to the right with a length of 10 squares.
(D) It should be an arrow to the right whose length depends on the chosen drawing scale.
(E) It should be an arrow to the left with a length of 10 squares.

15. Consider the vector $\vec{A} = 1\hat{i} + 3\hat{j}$ and the vector $\vec{B} = 5\hat{i}$.
Which option is the cross product $(\vec{A} \times \vec{B})$?
(A) $-15\hat{k}$
(B) $5\hat{i} + 15\hat{k}$
(C) $5\hat{i} + 3\hat{j}$
(D) $15\hat{k}$
(E) $6\hat{i} + 3\hat{j}$

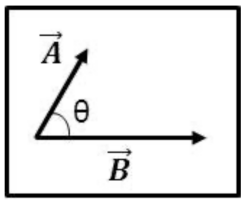
16. The figure below shows a force $\vec{F}$ that acts on a box and forms an angle ϕ with the vertical axis. $|\vec{F}|$ is the magnitude of the force $\vec{F}$. Which option shows the magnitude of the x-component of the force, i.e., $|\vec{F}_x|$?



(A) $|\vec{F}_x| = |\vec{F}| \tan\phi$
(B) $|\vec{F}_x| = \frac{|\vec{F}|}{\cos\phi}$
(C) $|\vec{F}_x| = |\vec{F}| \sin\phi$
(D) $|\vec{F}_x| = |\vec{F}| \cos\phi$
(E) $|\vec{F}_x| = \frac{|\vec{F}|}{\sin\phi}$

17. Consider two vectors for which $\vec{A} = \vec{B}$. Choose the option that is true if and only if two vectors are the same.
(A) The vectors have the same magnitude.
(B) The vectors point in the same direction.
(C) All scalar components of the vectors are the same.
(D) The dot product of the vectors is zero.
(E) The cross product of the vectors is zero.

18. The figure below shows vectors $\vec{A}$ and $\vec{B}$ that form the angle θ. $|\vec{A}|$ is the magnitude of vector $\vec{A}$ and $|\vec{B}|$ is the magnitude of vector $\vec{B}$. Which option is the magnitude of the cross product $(\vec{A} \times \vec{B})$?

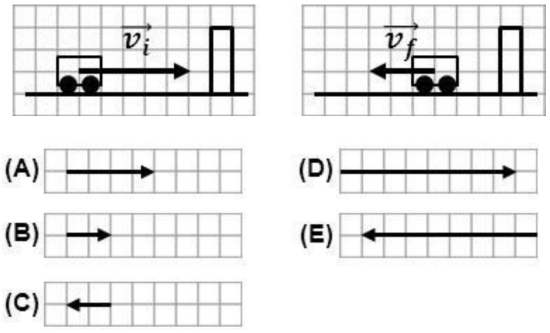


(A) $|\vec{A}| \cos\theta |\vec{B}| \sin\theta$
(B) $|\vec{A}||\vec{B}|$
(C) $|\vec{A}||\vec{B}| \sin(90° - \theta)$
(D) $|\vec{A}||\vec{B}| \sin\theta$
(E) $|\vec{A}||\vec{B}| \cos\theta$

19. Object A has the inital momentum $\vec{p}_{A,1} = (4 \text{ kgm/s})\hat{i}$. It collides with object B which is at rest. After the collision, A and B have the momenta $\vec{p}_{A,2}$ and $\vec{p}_{B,2}$, respectively. According to conservation of momentum, $\vec{p}_{A,1} = \vec{p}_{A,2} + \vec{p}_{B,2}$. Choose the option that is certainly true.
(A) Vectors $\vec{p}_{A,2}$ ja $\vec{p}_{B,2}$ must be parallel to the x-axis.
(B) $|\vec{p}_{x,A,2}| = |\vec{p}_{x,B,2}|$
(C) $|\vec{p}_{y,A,2}| = |\vec{p}_{y,B,2}|$
(D) $|\vec{p}_{A,2}| = |\vec{p}_{B,2}|$
(E) $|\vec{p}_{A,2}| + |\vec{p}_{B,2}| = 4$ kgm/s

20. An object has the velocity $\vec{\boldsymbol{v}} = (4 \text{ m/s})\hat{\boldsymbol{i}} + (-3 \text{ m/s})\hat{\boldsymbol{j}}$. Which option is the unit vector in the direction of the velocity vector?
(A) $(1 \text{ m/s})\hat{\boldsymbol{i}} + (-1 \text{ m/s})\hat{\boldsymbol{j}}$
(B) $4\hat{\boldsymbol{i}} - 3\hat{\boldsymbol{j}}$
(C) $\frac{4}{5}\hat{\boldsymbol{i}} - \frac{3}{5}\hat{\boldsymbol{j}}$
(D) $\left(\frac{4}{5} \text{ m/s}\right)\hat{\boldsymbol{i}} + \left(-\frac{3}{5} \text{ m/s}\right)\hat{\boldsymbol{j}}$
(E) $\left(\frac{4}{7} \text{ m/s}\right)\hat{\boldsymbol{i}} + \left(-\frac{3}{7} \text{ m/s}\right)\hat{\boldsymbol{j}}$

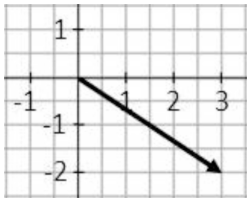
21. Consider a car colliding into a wall. The figure shows the initial velocity $\vec{\boldsymbol{v}}_i$ before the collision and the final velocity $\vec{\boldsymbol{v}}_f$ after the collision. Choose the option that shows the change of velocity vector that is the vector difference $\vec{\boldsymbol{v}}_f - \vec{\boldsymbol{v}}_i$.



22. Consider vectors for which $\vec{\boldsymbol{C}} = \vec{\boldsymbol{A}} + \vec{\boldsymbol{B}}$. Which option is true for the magnitudes of the these vectors: $|\vec{\boldsymbol{C}}|$, $|\vec{\boldsymbol{A}}|$ and $|\vec{\boldsymbol{B}}|$?

(A) $|\vec{\boldsymbol{C}}|$ is always equal to or greater than $|\vec{\boldsymbol{A}}| + |\vec{\boldsymbol{B}}|$.
(B) $|\vec{\boldsymbol{C}}|$ is always equal to $|\vec{\boldsymbol{A}}| + |\vec{\boldsymbol{B}}|$.
(C) $|\vec{\boldsymbol{C}}|$ is always equal to or less than $|\vec{\boldsymbol{A}}| + |\vec{\boldsymbol{B}}|$.
(D) $|\vec{\boldsymbol{C}}|$ may be less than, equal to or greater than $|\vec{\boldsymbol{A}}| + |\vec{\boldsymbol{B}}|$.
(E) $|\vec{\boldsymbol{C}}|$ is never equal to $|\vec{\boldsymbol{A}}| + |\vec{\boldsymbol{B}}|$.

23. The figure below shows vector $\vec{\boldsymbol{A}}$. Which option is the scalar component A_y?



(A) 2
(B) -2
(C) $2\hat{\boldsymbol{j}}$
(D) $-2\hat{\boldsymbol{j}}$
(E) $\sqrt{13}$

24. Object A has momentum $\vec{\boldsymbol{p}}_A$. The magnitude of this momentum is 3 kgm/s and it points in the positive x-direction. Object B has momentum $\vec{\boldsymbol{p}}_B$. The magnitude of this momentum is 4 kgm/s and it points in the positive y-direction. Which option is the total momentum $\vec{\boldsymbol{p}}_A + \vec{\boldsymbol{p}}_B$?

(A) 5
(B) 5 kgm/s
(C) 7 kgm/s
(D) $3\hat{\boldsymbol{i}} + 4\hat{\boldsymbol{j}}$
(E) $(3 \text{ kgm/s})\hat{\boldsymbol{i}} + (4 \text{ kgm/s})\hat{\boldsymbol{j}}$

25. Vectors $\vec{\boldsymbol{A}}$ and $\vec{\boldsymbol{B}}$ are perpendicular. Choose the option that is true if and only if two vectors are perpendicular.

(A) The vectors have the same magnitude.
(B) The vectors have at least one scalar component that is the same.
(C) All scalar components of the vectors are the same.
(D) The dot product of the vectors is zero.
(E) The cross product of the vectors is zero.