PHYSICS

BOOKS - AAKASH SERIES

ELEMENTS OF VECTORS

Problems

1. Three vectors $\vec{A}, \vec{B}, \vec{C}$ are shown in the figure. Find angle between (i) $\vec{A}$ and $\vec{B}$ (ii) $\vec{B}$

and $\vec{C}$, (iii) $\vec{A}$ and $\vec{C}$

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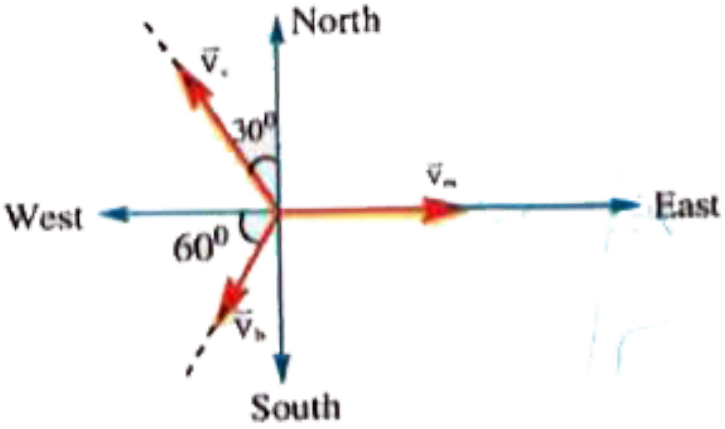
2. A man walks east with certain velocity .A car is travelling along a road which is 30° west of north . While a bus is travelling in another road which is 60° south of west . Find the angle between velocity vector of (a) man and

car (b) car and bus (c) bus and man



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3. A vector A makes on angle 30° with the y-axis in anticlockwise direction. Another vector B makes on angle 30° with the x-axis in

clockwise direction. Find angle between yectors A and B.

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4. Two forces 12 N and 16 N are acting upon a body, what can be the maximum and minimum resultant force on the body ?

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5. The resultant of two forces cannot exceed

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6. Let $\vec{a}$ and $\vec{b}$ be two vectors of the same magnitude such that the angle between them is $60^\circ C$ and $\vec{a}.\ \vec{b}$ =8. Find $\left|\vec{a}\right|$ and $\left|\vec{b}\right|$.

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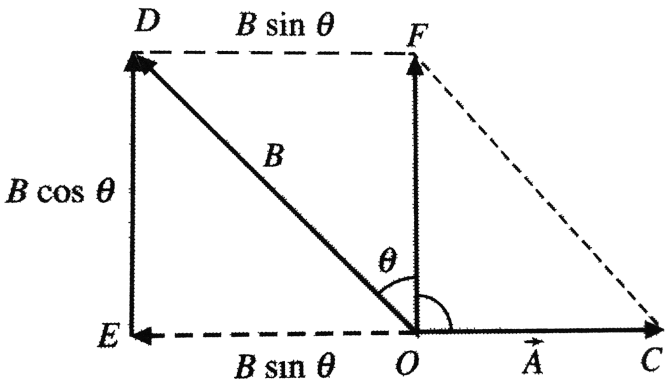
7. The resultant of two vectors $\vec{A}$ and $\vec{B}$ is perpendicular to the vector $\vec{A}$ and its magnitude is equal to half of the magnitude

of the vector $\vec{B}$. Find out the angles between $\vec{A}$ and $\vec{B}$.



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8. If the sum of two unit vectors is a unit vector, then the magnitude of their difference is :

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9. The sum of magnitudes of two forces acting at a point is $16N$. If their resultnat is normal to the smaller fore and has a magnitude of $8N$. Then the forces are

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10. Two forces whose magnitudes are in the ratio $3:5$ give a resultant of 28N. If the angle

of their inclination is 60°, find the magnitude of each force.

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11. Vector $\vec{A}$ is 2 cm long and is 60° above the x - axis in the first quadrant, vector $\vec{B}$ is 2cm long and is 60° below the x - axis in the fourth quadrant. Find $\vec{A} + \vec{B}$

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12. If vectors $\overrightarrow{A}$ and $\overrightarrow{B}$ are $3\hat{i}-4\hat{j}+5\hat{k}$ and $2\hat{i}+3\hat{j}-4\hat{k}$ respectively then the unit vector parallel to $\overrightarrow{A}+\overrightarrow{B}$

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13. If $A=3\hat{i}+4\hat{j}$ and $B=7\hat{i}+24\hat{j}$ the vector having the same magnitude as B and parallel to A is

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14. If vector $\vec{P} = a\hat{i} + a\hat{j} + 3\hat{k}$ and $\vec{Q} = a\hat{i} - 2\hat{j} - \hat{k}$ are perpendicular to each other , then the positive value of a is

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15. Find angle between $\vec{A} = 3\hat{i} + 4\hat{j}$ and $\vec{B} = 12\hat{i} + 5\hat{j}$?

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16. Two vectors $\vec{P}$ and $\vec{Q}$ are inclined to each other at angle θ. Which of the following is the unit vector perpendicular to $\vec{P}$ and $\vec{Q}$?

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17. find $\vec{A} \times \vec{B}$ if $\vec{A} = \hat{i} - 2\hat{j} + 4\hat{k}$ and $\vec{B} = 3\hat{i} - \hat{j} + 2\hat{k}$

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18. Let a force F be acting on a body free to rotate about a point O and let r the position vector of any point P on the line of action of the force. Then torque (τ) of this force about point O is defined as $\tau = r \times F$ Given, $F = \left(2\hat{i} + 3\hat{j} - \hat{k}\right)N$ and $r = \left(\hat{i} - \hat{j} + 6\hat{k}\right)m$ Find the torque of this force.

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19. IF $\vec{A} = \left(2\hat{i} + \hat{j}\right)$ and $\vec{B} = \hat{i} - \hat{j} + 5\hat{k}$ find $(i)\vec{A} \times \vec{B}$ (ii) angle between $\vec{A}$ and $\vec{B}$ (iii) unit vector perpendicular to $\vec{A}$ and $\vec{B}$.

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20. Calculate the work done if a particle displaces through $\left(2\hat{i} - \hat{j} + 5\hat{k}\right)$ meter under a force $\left(4\hat{i} + 2\hat{j} - \hat{k}\right)$ newton (work = $\vec{F} . \vec{S}$)

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21. IF $\vec{A} \times \vec{B} = \vec{C} \times \vec{D}$ and $\vec{A} \times \vec{C} = \vec{B} \times \vec{D} +$ while $\left|\vec{A}\right| \neq \left|\vec{D}\right| \left|\vec{B}\right| \neq \left|\vec{C}\right|$ show $\left(\vec{A} - \vec{D}\right)$ that and $\left(\vec{B} - \vec{C}\right)$ are parallel

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22. What is the displacement of the point of a wheel initially in contact with the ground when the wheel rolls forward half a

revolution? Take the radius of the wheel as R and the x-axis as the forward direction?

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23. An object A is moving with 5 m/s and B is moving with 20 m/s in the same direction. (Positive x-axis). Find a) velocity of B relative to A.

b) Velocity of A relative to B

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24. An object A is moving with 5 m/s and B is moving with 20 m/s in the same direction. (Positive x-axis). Find a) velocity of B relative to A.

b) Velocity of A relative to B

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25. Two objects A and B are moving towards each other with velocities 10 m/s and 12 m/s respectively as shown

(i) find out velocity of A with respect to B .

(ii) find out velocuty of B with respect to A

View Text Solution

26. A and B are thrown vertivally upward with velocity 5m/s and 10 m/s respectively $\left(g = 10m/s^2\right)$. Find separtion between them after one second .

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27. A ball is throuwn with a speed of 20 m//s from top of a buling 150 m high and simultaneously another ball is thrown vertically upward witn a speed of 30 m/s from the foot of the builing . Find the time when both the balls will meet $\left(g = 10m/s^2\right)$

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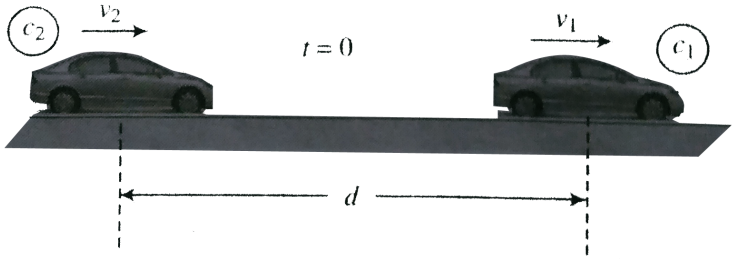
28. Two cars C_1 and C_2 moving in the same direction on a straight single lane road with

velocities $v_1 = 12ms^{-1}$ and $v_2 = 10ms^{-1}$, respectively . When the separation between the two was $d = 200m$, C_2 started accelerating to avoid collision. What is the minimum acceleration of car C_2 so that they do not collide?



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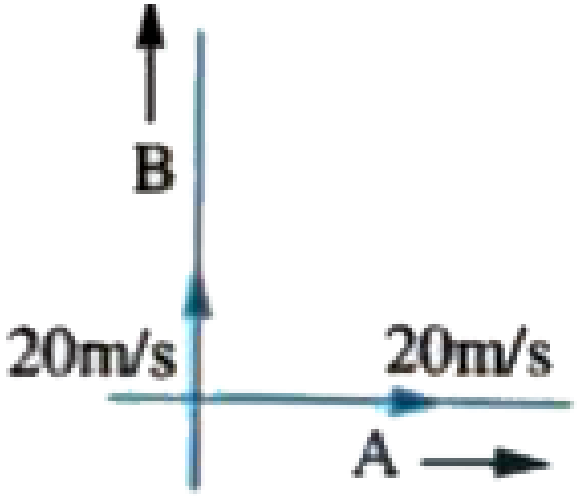
29. Consdier the situation shown in figure

(I) find out velocity of B with respect to A

(ii) Find out velocity of A with respect to B



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30. Two object A and B are moving each with velocities 10 m/s. A is moving towards East and B is moving towards North from the same point as shown. Find velocity of A relative to B $\left(\vec{V}_{AB}\right)$

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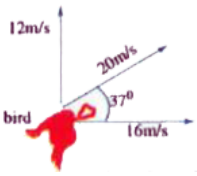
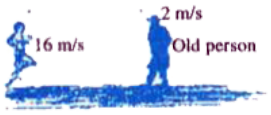
31.





find out motion of tree boy as seen bu old man .

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32. 

find out motion of tree boy as seen bu old man .

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33. 

find out motion of tree boy as seen bu old

man .

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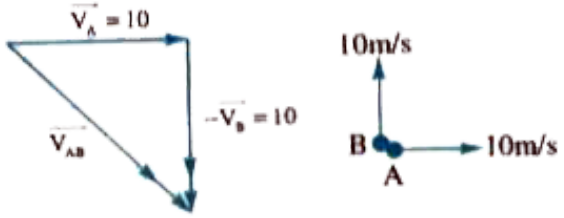
34. Two particles A and B are projected in air .A is thrown horizontally .B is thrown vertically up . What is the separation between them after 1 sec .



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35. A swimmer capable of swimming with velocity v relative to water jumps in a flowing river having velocity u. The man swims a distance d down stream and returns back to the original position. Find out the time taken in complete motion.

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36. A river $400m$ wide is flowing at a rate of $2.0m/s$. A boat is sailing at a velocity of

$10.0m/s$ with respect to the water In a direction perpendicular to the river.

(a) Find the time taken by the boat to reach the opposite bank.

(b) How far from the point directly opposite to the starting point does the boat reach the opposite bank?

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37. A river $400m$ wide is flowing at a rate of $2.0m/s$. A boat is sailing at a velocity of

$10.0m/s$ with respect to the water In a direction perpendicular to the river.

(a) Find the time taken by the boat to reach the opposite bank.

(b) How far from the point directly opposite to the starting point does the boat reach the opposite bank?

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38. A river 400 m wide is flowing at a rate of 2.0 m/s. A boat is sailing at a velocity of 10 m/s

wilth respect to the water, in a direction perpendicular toteh river.a. Find the time taken by the boat to reach the opposite bank. b. How far from the point directly opposite to the starting point does tbhe boad reach the opposite bank?

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39. A ,man wishing to cross a river flowing with velocity u jumps at an angle θ with the river flow.

(a) Find the net velocity of the man with respect to ground if he can swim with speed v in still water.

(b) In what direction does the boat actually move ?

(c) Find how far from the point directly opposite to the starting point does the boat reach the opposite bank, if the width of the river is d.

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40. A boat moves relative to water with a velocity with a velocity v is n times less than the river flow u. At what angle to the stream direction must the boat move to minimize drifting ?

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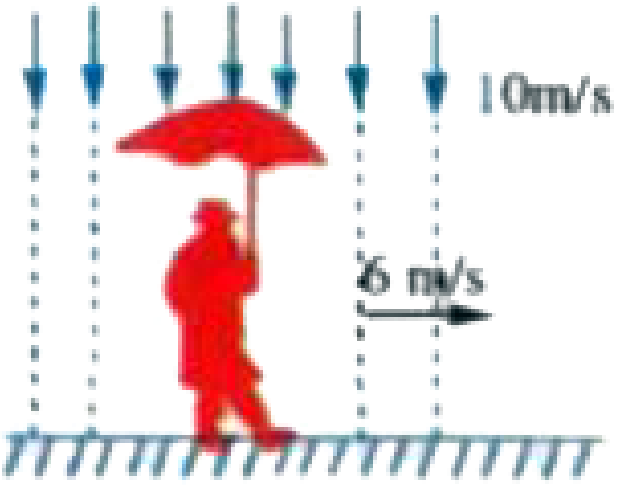
41. Rain is falling vertically and a man is moving with velocity 6m/s find the angle with which umbrella should be held by man to

avoid getting wet .



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42. A man moving with $5ms^{-1}$ observes rain falling vertically at the rate of $10ms^{-1}$. Find

the speed and direction of the rain with respect to ground.

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43. A standing man observes rain falling with the velocity of $20ms^{-1}$ at an angle of 30° with the vertical.

(a) Find the velocity with which the man should move so that rain appears to fall vertically to him.

Now if he further increases his speed, rain

again appears to fall at 30° with the vertical. Find his new velocity.

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44. A standing man observes rain falling with the velocity of $20ms^{-1}$ at an angle of 30° with the vertical.

(a) Find the velocity with which the man should move so that rain appears to fall vertically to him.

Now if he further increases his speed, rain

again appears to fall at 30° with the vertical. Find his new velocity.

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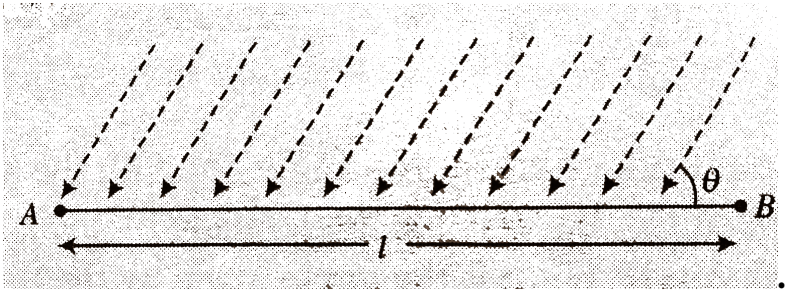
45. An aeroplane flies along a straight path A and B and returns back again. The distance between A and B is l and the aeroplane maintains the constant speed v w.r.t. wind.

There is a steady wind with a speed u at an angle θ with line AB. Determine the

expression for the total time of the trip.



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46. What are the speeds of two objects if they move uniformly towards each other, they get 4 m closer in each second and if they move uniformly in the same direction with the original speeds they get 4 m closer in each 10 sec?

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47. A river is flowing from west to east at a speed of $5 metres per \min ute$. A man on the south bank of the river , capable of swimming at $10 metres per \min ute$, in still water , wants to swim across the river in the shortest time . He should swim in a direction

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48. A car A is traveling on a straight level road with a uniform speed of 60 km/h. It is followed by another car B which is moving with a speed of 70 km/h. When the distance between them is 2.5 km, the car B is given a deceleration of $20\mathrm{km}/\mathrm{h}^2$. After what distance and time will B catch up with A

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49. A boat which has a speed of $5kmh^{-1}$ in still water crosses a river of width 1 km along the shortest possible path in 15 min. The velocity of the river water in kmh^{-1} is

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50. Rain is falling vertically with a velocity of 4 km hr^{-1} . A cyclist is going along a horizontal road with a velocity of 3 km hr^{-1} towards cast. Calculate the relative velocity of the rain

with respect to the cyclist. In what direction must the cyclist hold his umbrella to save himself from the falling rain ?

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51. A cat is chasing a mouse as shown in the figure . The mouse runs horizontally with speed 19m/s. The cat runs with a constnat speed of 20m/s. At which angle to the horizontal should the cat run in order to catch the mouse ?

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52. A man standing still finds rain pouring at angle 30° with vertical , when he starts walking forward at a speed of 4Kmph it appears to him that rain pours vertically down. When he runs at triple the speed, what is the

angle at which rain appers to pour ?

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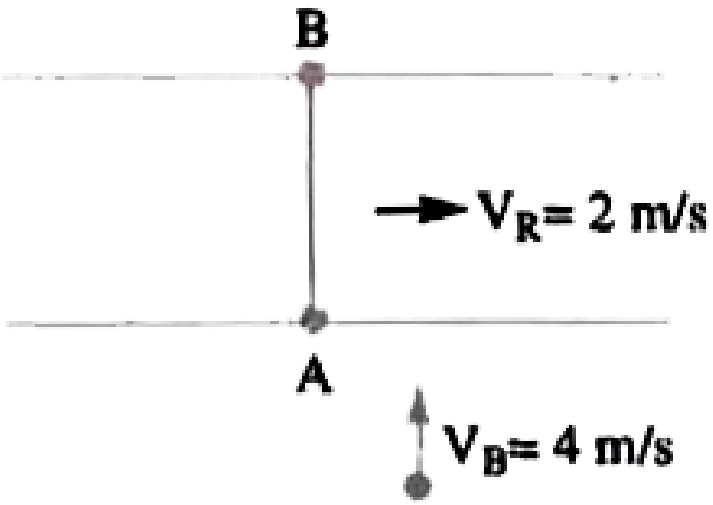
53. A man wishes to row across a river flowing to the right with speed of 2m/s. If they velocity that the boat can have $V_B = 4m/s$, how

should the man row so as to reach across in .

(a) shortest path (b) shortest time .



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54. A man floating on a raft in water flowing at 2kmph observes a motor lauch overtaking him

at t = 0. Then lauch travels with the speed of 20kmp relative to still water . After travelling for a time of 1 hr , the lauch turns back towards raft.How far from from the original point of crossing do they meet and what is the total time elapsed ?

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Long Answer Type Questions

1. State parallelogram law of vector addition. Find analytically the magnitude and direction of resultant vector. Apply it to find the resultant when,

(i) Two vectors are parallel to each other

(ii) Two vectors are perpendicular to each other

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2. Define scalar and vector products. Describe them with examples.

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3. Explain the triangle law and polygon law of vectors.

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4. Define scalar product Describe the scalar product with two examples. Also mention the properties of scalar product.

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5. Define vector product. Describe vector product of two vectors with at least two examples. Mention the properties of vector product.

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Short Answer Type Questions

1. Define scalar and vector products. Describe them with examples.

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2. State parallelogram law of vector addition. Find analytically the magnitude and direction of resultant vector. Apply it to find the resultant when,

(i) Two vectors are parallel to each other

(ii) Two vectors are perpendicular to each other

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3. Define unit vector, null vector and position vector .

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4. What is scalar product of two vectors ? Give two examples .

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5. What is vector product of two vectors ? Give two examples .

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6. Explain the law of addition of vectors.

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7. State triangle law of of vector addition .

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8. Explain the triangle law and polygon law of vectors.

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9. Explain the dot product and cross product of unit vectors.

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10. Write the formula of the scalar product of two vectors explaining the symbols.

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Very Short Answer Type Questions

1. If the vectors $2\hat{i}+2\hat{j}-\hat{k}$ and $3\hat{i}-6\hat{j}+n\hat{k}$ are mutually perpendicular, find the value of n ?

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2. The vertical component of a vector is equal to its horizontal component. What is the angle made by the vector with x-axis ?

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3. If $\vec{F} = 3\hat{i} - 4\hat{j} + 5\hat{k}$ and $\vec{S} = 6\hat{i} + 2\hat{j} + 5\hat{k}$, the find the work done.

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4. Two vectors 3 units and 5 units are acting at 60° to each other .What is the magnitude and direction of the resultant ?

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5. A = $\vec{i} + \vec{j}$. What is the angle between the vector and x-axis ?

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6. When two right angled vectors of magnitude 7 units and 24 units combine, what is the magnitude of their resultant ?

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7. If $\vec{P} = 2\hat{i} + 4\hat{j}$ and $\vec{Q} = 4\hat{i} - 4\hat{j} + 10\hat{k}$ find the magnitude of $\vec{P} + \vec{Q}$

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8. A force $2\bar{i} + \bar{j} - \bar{k}$ Newton acts on a body which is initially at rest . At the end of 20 seconds the velocity of the body is $4\bar{i} + 2\bar{j} - 2\bar{k}$ m/s . What is the mass of the body ?

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9. find the work in moving an object through a displacement $2\hat{i}+3\hat{j}+5\hat{k}$ when the applied force is $5\hat{i}-4\hat{j}+2\hat{k}$

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10. If $\left|\vec{a}+\vec{b}\right|=\left|\vec{a}-\vec{b}\right|$, then what is the angle between $\vec{a}$ and $\vec{b}$?

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11. If $\vec{a} = 4\hat{i} - 3\hat{j}$ then find the value of $\left|\vec{a}\right|$

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12. If $\vec{a} . \vec{b} = 0$, then what is the angle between $\vec{a}$ and $\vec{b}$?

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Numerical Exxercise Level 1

1. A particle of mass 3kg. moves under the force of $4\hat{i} + 8\hat{j} + 10\hat{k}N$. If the particle starts from rest and was at origin initially. Its new co-ordinates after 3 second is:-

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2. The scalar and vector products of two vectors are $48\sqrt{3}$ and 144 respectively. What is angle between the two vectors?

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3. vecA and vecB are vectors such that A +BI= I A -B j. Then, the angle between them is

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4. Two forces $\vec{F}_1$ and $\vec{F}_2$ are acting on a body. One force is double that of the other force and the resultant is equal to the greater force. Then the angle between the two forces is :

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5. if $\vec{A}_{\vec{B}} = \vec{C}$ and $A + B = C$, then the angle between $\vec{A}$ and $\vec{B}$:

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6. The greatest & the least magnitude of the resultant of two forces of constant magnitudes are P & Q respectively. If the forces act at an angle 2α, then prove that the

magnitude of their resultant is given by $\sqrt{P^2 \cos^2 \alpha + Q^2 \sin^2 \alpha}$.

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7. The resultant R of two forces P and Q acting at an angle θ (obtuse angle i.e. $\theta > 90^\circ$) is given by

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8. If the difference of two unit vectors is also a vector of unit magnitude, the magnitude of the sum of the two unit vectors is

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9. Two magnets of moment M and 2 M are tied at an angle of 60° to each other . What is the resultant magnetic moment of the combination ?

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10. If $\vec{a}, \vec{b}$ and $\vec{c}$ are three vectors such that $\vec{a} + \vec{b} = \vec{c}$ and further $a^2 + b^2 = c^2$, find the angle between them $\vec{a}$ and $\vec{b}$?

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11. A vector is represented by $3\hat{i} + \hat{j} + 2\hat{k}$ Its langth in Xy - plane is

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12. If a unit vector is represented by $0.5\hat{i} + 0.8\hat{j} + c\hat{k}$ the value of c is

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13. If $A = 3\hat{i} + 4\hat{j}$ and $B = 7\hat{i} + 24\hat{j}$ the vector having the same magnitude as B and parallel to A is

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Numerical Exxercise Level 2

1. The width of a river is $3\sqrt{3}$ km. A boat has a velocity of $\sqrt{3}$ km/s and starts to cross the river in a direction perpendicular to the bank of the river. If the river is flowing with a velocity 2km/sec, find the distance drifted by the boat.

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2. Two vectors of equal magnitude have a resultant equal to either of them in

magnitude. The angle between them is :

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3. A force $\left(2\hat{i}+3\hat{j}-\hat{k}\right)$ newtons acts on a particle having position vector $\left(\hat{i}-\hat{j}+2\hat{k}\right)$. Find the torque of the force about origin.

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4. A body of mass 10 kg is suspended by a string and is pulled a side with a horizontal

force of 49 N. Find the tension in the string, if the body is in equilibrium under these forces.

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5. A man is travelling at 10.8 kmph in a topless car on a rainy day. He holds an umbrella at an angle of 37° with the vertical so that he does not wet. If rain drops falls vertically downwards, what is the rain velocity ?

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6. A body starts with a velocity $2\hat{i} + 3\hat{j} + 11\hat{k}$ m/s and moves with an acceleration $10\hat{i} + 10\hat{j} + 10\hat{k} m/s^2$. What is its velocity after 0.2 seconds ?

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7. Prove that when the sides of a triagle are taken in order, it leads to zero resultant.

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8. Resultant of two vector of equal magnitude A is

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9. A vector makes angle with X,Y and Z axer that are in the ratio $1:2:1$ respectively. The angle made by the vector with Y-axis is

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10. The components of a particles velocity in the directions at right angles are $3m/s, 4m/s$ and $12m/s$ respectively . The actual velocity of the particle , in m/s is

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11. Two vectors $\vec{P}$ and $\vec{Q}$ are having their magnitudes in the ratio $\sqrt{3}:1$. *Further* $\vec{P}+\vec{Q} = \vec{P}-\vec{Q}$

then the angle between the vectors $\left(\vec{P}+\vec{Q}\right)$ and $\left(\vec{P}-\vec{Q}\right)$ is

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12. A vector makes angles $\alpha, \beta \text{and} \gamma$ with the X,Y and Z axes respectively . Find the value of the expression $\frac{\sin^2\alpha+\sin^2\beta+\sin^2\gamma}{\cos^2\alpha+\cos^2\beta+\cos^2\gamma}$

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13. At a given instant of time two particles are having the position vectors $4\hat{i} - 4\hat{j} + 7\hat{k}$ metre and $2\hat{i} + 2\hat{j} + 5\hat{k}$ respectively. If the velocity of the first particle be $0.4\hat{i} ms^{-1}$, the velocity of second particle in metre per second if they collide after 10 s is

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14. IF $\overline{P} + \overline{Q} = \overline{R}$ and $P = Q = \frac{R}{\sqrt{2}}$ then find the angles between the pairs of vectors

$(\overline{P}, \overline{Q}), (\overline{Q}, \overline{R})$ and $(\overline{R}, \overline{P})$ respectively

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15. The sum of the magnitudes of wto forces acting at a point is 18 and the magnitude of their resultant is 12 If the resultant is at 90° with the force of smaller magnitude , what aarae the magnitude of fores ?

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16. Two particles A And B , move with constant velocities v_1 and v_2 At the initial moment their position vectors are r_1 and r_2 respectively. The condition for particle A and B for their collision is

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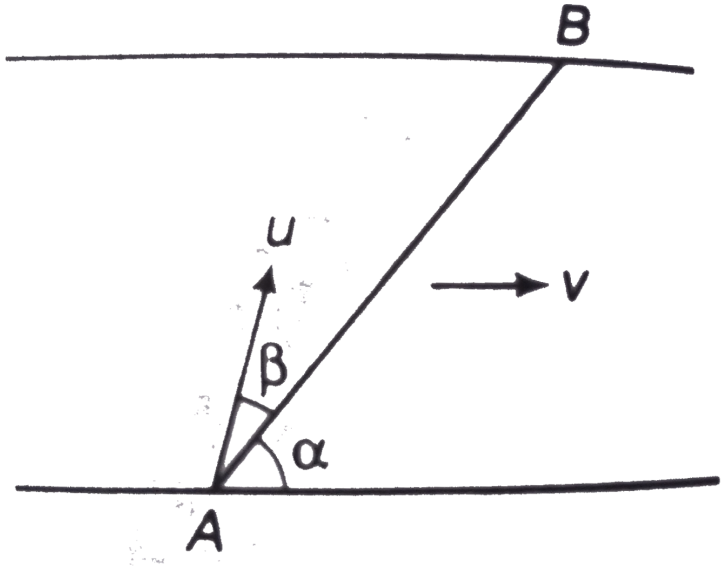
17. A launch plies between two points A and B on the opposite banks of a river always following the line AB. The distance S between

points and B is 1200 m. The velocity of the river current $v = 1.9m/s$ is constant over the entire width of the river. The line AB makes an angle $\alpha = 60^\circ$ with the direction of the current. With what velocity u and at what angle beta to the line AB should the launch move to cover the distance AB and back in a time $t = 5\ \mathrm{min}$? The angle beta remains the same during the passage from A to B and from

B to A.



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18. A boat moves perpendicular to the bank with a velocity of 7.2 km/h. The current carries

it 150 m downstream, find the velocity of the current. (The width of the river is 0.5 km).

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19. An aeroplane is flying with a velocity 800kmph relative to air wind is belong from west to east with a velocity $15ms^{-1}$. Find velocity of aeroplane relative to the earth to fly south ward

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20. A swimmer is capable of swimming at 1.65ms- in still water. If he swims directly across a 180m wide river with water flow at $0.85ms^{-1}$', how far down stream will he reach? How long will it take to reach the other side ?

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21. A boat moves relative to water with a velocity with a velocity v is n times less than the river flow u. At what angle to the stream

direction must the boat move to minimize drifting ?

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Questions For Descriptive Answers

1. Find the components of a vector $A = 2\hat{i} + 3\hat{j}$ along the directions of $\hat{i} + \hat{j}$ and $\hat{i} - \hat{j}$.

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2. Three vector each of magnitude A are acting at a point such that angle between any two consecuitve vectors in same plane is 60° The magniude of their resultant is

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3. A man can swim at the rate of $5kmh^{-1}$ in still water. A $1-km$ wide river flows at the rate of $3kmh^{-1}$ The man wishes to swim across the river directly opposite to the starting point.

(a) Along what direction must the man swim ?

(b) What should be his resultant velocity ?

(c) How much time will he take to cross the river ?

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4. Two cars A and B are moving west to east and south to north, respectively, along crossroads. A moves with a speed of $20ms^{-1}$ and is $500m$ away from the point of intersection of cross roads and B moves with

a speed of $15ms^{-1}$ and is $400m$ away from the point of intersection of cross roads. Find the shortest distance between them.

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5. Two ships A and B are 4 km apart. A is due west of B. If A moves with a uniform velocity of 8 km hr^{-1} due east and B moves with a uniform velocity of 6 km hr^{-1} due south, calculate (i) the magnitude of velocity of A

relative to B, (ii) the closest distance apart of A and B.

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6. A vector $\overline{Q}$which has a magnitude of 8 is added to the vector $\overline{P}$ which lies along the X-axis. The resultant of these two vectors is a third vector $\overline{R}$ which lies along the Y-axis and has a magnitude twice that of $\overline{P}$. The magnitude of $\overline{P}$ is

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7. Four vectors $\bar{a}, \bar{b}, \bar{c}, \text{ and } \bar{d}$ are lying in the same plane. The vectors $\bar{a}$ and $\bar{b}$ are equal in magnitude and inclined to each other at an angle of 120°. $\overline{C}$ is the resultant of $\bar{a}$ and $\bar{b}$. Further $\bar{a}+\bar{b}+\bar{d}=0$. If the angle between $\bar{a}$ and $\bar{d}$ is β and the angle between $\bar{a}$ and $\bar{c}$ is a, find the correct relation between α and β

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8. A man is travelling at 10.8 kmph in a topless car on a rainy day. He holds an umbrella at an angle of 37° with the vertical to protect himself from rain which is falling vertically downwards. What is the velocity of the rain drop ?

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9. An observer is travelling in east with a velocity of 2 m/s and observes that wind is

blowing in north with a velocity of 2m/s. If observer doubles his velocity then find out the velocity of wind appears to observer ?

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10. The adjacent sides of a parallelogram $ABCD$ measure $34cmand20cm,$ and the diagonal AC measures $42cm.$ Find the area of the parallelogram.

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