

## EXERCISE 8.1

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1. In  $\triangle ABC$ , right-angled at B,  $AB = 24$  cm,  $BC = 7$  cm. Determine:

(i)  $\sin A$ ,  $\cos A$

(ii)  $\sin C$ ,  $\cos C$

Solution:

In a given triangle ABC, right angled at B =  $\angle B = 90^\circ$

Given:  $AB = 24$  cm and  $BC = 7$  cm

According to the Pythagoras Theorem,

In a right- angled triangle, the squares of the hypotenuse side is equal to the sum of the squares of the other two sides.

By applying Pythagoras theorem, we get

$$AC^2 = AB^2 + BC^2$$

$$AC^2 = (24)^2 + 7^2$$

$$AC^2 = (576 + 49)$$

$$AC^2 = 625 \text{ cm}^2$$

$$AC = \sqrt{625} = 25$$

Therefore,  $AC = 25$  cm

(i) To find  $\sin A$ ,  $\cos A$

We know that sine (or) Sin function is the equal to the ratio of length of the opposite side to the hypotenuse side. So it becomes

$$\sin A = \text{Opposite side} / \text{Hypotenuse} = BC/AC = 7/25$$

Cosine or Cos function is equal to the ratio of the length of the adjacent side to the hypotenuse side and it becomes,

$$\cos A = \text{Adjacent side} / \text{Hypotenuse} = AB/AC = 24/25$$

(ii) To find  $\sin C$ ,  $\cos C$

$$\sin C = AB/AC = 24/25$$

$$\cos C = BC/AC = 7/25$$

2. In Fig. 8.13, find  $\tan P - \cot R$

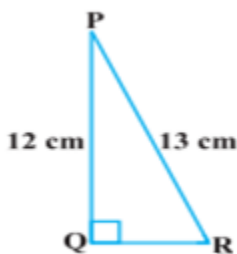


Fig. 8.13

Solution:

In the given triangle PQR, the given triangle is right angled at Q and the given measures are:

$$PR = 13\text{cm},$$

$$PQ = 12\text{cm}$$

Since the given triangle is right angled triangle, to find the side QR, apply the Pythagorean theorem

According to Pythagorean theorem,

In a right- angled triangle, the squares of the hypotenuse side is equal to the sum of the squares of the other two sides.

$$PR^2 = QR^2 + PQ^2$$

Substitute the values of PR and PQ

$$13^2 = QR^2 + 12^2$$

$$169 = QR^2 + 144$$

$$\text{Therefore, } QR^2 = 169 - 144$$

$$QR^2 = 25$$

$$QR = \sqrt{25} = 5$$

Therefore, the side QR = 5 cm

To find  $\tan P - \cot R$ :

According to the trigonometric ratio, the tangent function is equal to the ratio of the length of the opposite side to the adjacent sides, the value of  $\tan (P)$  becomes

$$\tan (P) = \text{Opposite side / Adjacent side} = QR/PQ = 5/12$$

Since cot function is the reciprocal of the tan function, the ratio of cot function becomes,

$$\cot (R) = \text{Adjacent side/Opposite side} = QR/PQ = 5/12$$

Therefore,

$$\tan (P) - \cot (R) = 5/12 - 5/12 = 0$$

$$\text{Therefore, } \tan(P) - \cot(R) = 0$$

**3. If  $\sin A = 3/4$ , calculate  $\cos A$  and  $\tan A$ .**

Solution:

Let us assume a right angled triangle ABC, right angled at B

Given:  $\sin A = 3/4$

We know that, Sin function is the equal to the ratio of length of the opposite side to the hypotenuse side.

Therefore,  $\sin A = \text{Opposite side} / \text{Hypotenuse} = 3/4$

Let BC be  $3k$  and AC will be  $4k$

where  $k$  is a positive real number.

According to the Pythagoras theorem, the squares of the hypotenuse side is equal to the sum of the squares of the other two sides of a right angle triangle and we get,

$$AC^2 = AB^2 + BC^2$$

Substitute the value of AC and BC

$$(4k)^2 = AB^2 + (3k)^2$$

$$16k^2 - 9k^2 = AB^2$$

$$AB^2 = 7k^2$$

Therefore,  $AB = \sqrt{7}k$

Now, we have to find the value of  $\cos A$  and  $\tan A$

We know that,

$\cos(A) = \text{Adjacent side} / \text{Hypotenuse}$

Substitute the value of AB and AC and cancel the constant  $k$  in both numerator and denominator, we get

$$AB/AC = \sqrt{7}k/4k = \sqrt{7}/4$$

Therefore,  $\cos(A) = \sqrt{7}/4$

$\tan(A) = \text{Opposite side} / \text{Adjacent side}$

Substitute the Value of BC and AB and cancel the constant  $k$  in both numerator and denominator, we get,

$$BC/AB = 3k/\sqrt{7}k = 3/\sqrt{7}$$

Therefore,  $\tan A = 3/\sqrt{7}$

#### 4. Given $15 \cot A = 8$ , find $\sin A$ and $\sec A$ .

Solution:

Let us assume a right angled triangle ABC, right angled at B

Given:  $15 \cot A = 8$

So,  $\cot A = 8/15$

We know that, cot function is the equal to the ratio of length of the adjacent side to the opposite side.

Therefore,  $\cot A = \text{Adjacent side} / \text{Opposite side} = AB/BC = 8/15$

Let AB be  $8k$  and BC will be  $15k$

Where,  $k$  is a positive real number.

According to the Pythagoras theorem, the squares of the hypotenuse side is equal to the sum of the squares of the other two sides of a right angle triangle and we get,

$$AC^2 = AB^2 + BC^2$$

Substitute the value of  $AB$  and  $BC$

$$AC^2 = (8k)^2 + (15k)^2$$

$$AC^2 = 64k^2 + 225k^2$$

$$AC^2 = 289k^2$$

$$\text{Therefore, } AC = 17k$$

Now, we have to find the value of  $\sin A$  and  $\sec A$

We know that,

$$\sin(A) = \text{Opposite side} / \text{Hypotenuse}$$

Substitute the value of  $BC$  and  $AC$  and cancel the constant  $k$  in both numerator and denominator, we get

$$\sin A = BC/AC = 15k/17k = 15/17$$

$$\text{Therefore, } \sin A = 15/17$$

Since secant or sec function is the reciprocal of the cos function which is equal to the ratio of the length of the hypotenuse side to the adjacent side.

$$\sec(A) = \text{Hypotenuse} / \text{Adjacent side}$$

Substitute the Value of  $BC$  and  $AB$  and cancel the constant  $k$  in both numerator and denominator, we get,

$$AC/AB = 17k/8k = 17/8$$

$$\text{Therefore } \sec(A) = 17/8$$

### 5. Given $\sec \theta = 13/12$ Calculate all other trigonometric ratios

Solution:

We know that sec function is the reciprocal of the cos function which is equal to the ratio of the length of the hypotenuse side to the adjacent side

Let us assume a right angled triangle  $ABC$ , right angled at  $B$

$$\sec \theta = 13/12 = \text{Hypotenuse} / \text{Adjacent side} = AC/AB$$

Let  $AC$  be  $13k$  and  $AB$  will be  $12k$

Where,  $k$  is a positive real number.

According to the Pythagoras theorem, the squares of the hypotenuse side is equal to the sum of the squares of the other two sides of a right angle triangle and we get,

$$AC^2 = AB^2 + BC^2$$

Substitute the value of  $AB$  and  $AC$

$$(13k)^2 = (12k)^2 + BC^2$$

$$169k^2 = 144k^2 + BC^2$$

$$169k^2 = 144k^2 + BC^2$$

$$BC^2 = 169k^2 - 144k^2$$

$$BC^2 = 25k^2$$

$$\text{Therefore, } BC = 5k$$

Now, substitute the corresponding values in all other trigonometric ratios

So,

$$\sin \theta = \text{Opposite Side/Hypotenuse} = BC/AC = 5/13$$

$$\cos \theta = \text{Adjacent Side/Hypotenuse} = AB/AC = 12/13$$

$$\tan \theta = \text{Opposite Side/Adjacent Side} = BC/AB = 5/12$$

$$\operatorname{cosec} \theta = \text{Hypotenuse/Opposite Side} = AC/BC = 13/5$$

$$\cot \theta = \text{Adjacent Side/Opposite Side} = AB/BC = 12/5$$

**6. If  $\angle A$  and  $\angle B$  are acute angles such that  $\cos A = \cos B$ , then show that  $\angle A = \angle B$ .**

Solution:

Let us assume the triangle ABC in which  $CD \perp AB$

Give that the angles A and B are acute angles, such that

$$\cos(A) = \cos(B)$$

As per the angles taken, the cos ratio is written as

$$AD/AC = BD/BC$$

Now, interchange the terms, we get

$$AD/BD = AC/BC$$

Let take a constant value

$$AD/BD = AC/BC = k$$

Now consider the equation as

$$AD = k BD \dots(1)$$

$$AC = k BC \dots(2)$$

By applying Pythagoras theorem in  $\triangle CAD$  and  $\triangle CBD$  we get,

$$CD^2 = BC^2 - BD^2 \dots(3)$$

$$CD^2 = AC^2 - AD^2 \dots(4)$$

From the equations (3) and (4) we get,

$$AC^2 - AD^2 = BC^2 - BD^2$$

Now substitute the equations (1) and (2) in (3) and (4)

$$K^2(BC^2 - BD^2) = (BC^2 - BD^2) \quad k^2 = 1$$

Putting this value in equation, we obtain

$$AC = BC$$

$\angle A = \angle B$  (Angles opposite to equal side are equal-isosceles triangle)

**7. If  $\cot \theta = 7/8$ , evaluate :**

**(i)  $(1 + \sin \theta)(1 - \sin \theta)/(1 + \cos \theta)(1 - \cos \theta)$**

**(ii)  $\cot^2 \theta$**

Solution:

Let us assume a  $\triangle ABC$  in which  $\angle B = 90^\circ$  and  $\angle C = \theta$

Given:

$$\cot \theta = BC/AB = 7/8$$

Let  $BC = 7k$  and  $AB = 8k$ , where  $k$  is a positive real number

According to Pythagoras theorem in  $\triangle ABC$  we get.

$$AC^2 = AB^2 + BC^2$$

$$AC^2 = (8k)^2 + (7k)^2$$

$$AC^2 = 64k^2 + 49k^2$$

$$AC^2 = 113k^2$$

$$AC = \sqrt{113} k$$

According to the sine and cos function ratios, it is written as

$$\sin \theta = AB/AC = \text{Opposite Side/Hypotenuse} = 8k/\sqrt{113} k = 8/\sqrt{113} \text{ and}$$

$$\cos \theta = \text{Adjacent Side/Hypotenuse} = BC/AC = 7k/\sqrt{113} k = 7/\sqrt{113}$$

Now apply the values of sin function and cos function:

$$(i) \frac{(1 + \sin \theta)(1 - \sin \theta)}{(1 + \cos \theta)(1 - \cos \theta)} = \frac{1 - \sin^2 \theta}{1 - \cos^2 \theta}$$

$$= \frac{1 - \left(\frac{8}{\sqrt{113}}\right)^2}{1 - \left(\frac{7}{\sqrt{113}}\right)^2} = \frac{49}{64}$$

$$(ii) \cot^2 \theta = \left(\frac{7}{8}\right)^2 = \frac{49}{64}$$

**8. If  $3 \cot A = 4$ , check whether  $(1 - \tan^2 A)/(1 + \tan^2 A) = \cos^2 A - \sin^2 A$  or not.**

Solution:

Let  $\triangle ABC$  in which  $\angle B = 90^\circ$

We know that, cot function is the reciprocal of tan function and it is written as

$$\cot(A) = AB/BC = 4/3$$

Let  $AB = 4k$  and  $BC = 3k$ , where  $k$  is a positive real number.

According to the Pythagorean theorem,

$$AC^2 = AB^2 + BC^2$$

$$AC^2 = (4k)^2 + (3k)^2$$

$$AC^2 = 16k^2 + 9k^2$$

$$AC^2 = 25k^2$$

$$AC = 5k$$

Now, apply the values corresponding to the ratios

$$\tan(A) = BC/AB = 3/4$$

$$\sin(A) = BC/AC = 3/5$$

$$\cos(A) = AB/AC = 4/5$$

Now compare the left hand side(LHS) with right hand side(RHS)

$$\text{L.H.S.} = \frac{1 - \tan^2 A}{1 + \tan^2 A} = \frac{1 - \left(\frac{3}{4}\right)^2}{1 + \left(\frac{3}{4}\right)^2} = \frac{1 - \frac{9}{16}}{1 + \frac{9}{16}} = \frac{7}{25}$$

$$\text{R.H.S.} = \cos^2 A - \sin^2 A = \left(\frac{4}{5}\right)^2 - \left(\frac{3}{5}\right)^2 = \frac{16}{25} - \frac{9}{25} = \frac{7}{25}$$

Since, both the LHS and RHS =  $7/25$

$$\text{R.H.S.} = \text{L.H.S.}$$

Hence,  $(1 - \tan^2 A)/(1 + \tan^2 A) = \cos^2 A - \sin^2 A$  is proved

**9. In triangle ABC, right-angled at B, if  $\tan A = 1/\sqrt{3}$  find the value of:**

**(i)  $\sin A \cos C + \cos A \sin C$**

**(ii)  $\cos A \cos C - \sin A \sin C$**

Solution:

Let  $\triangle ABC$  in which  $\angle B = 90^\circ$

$$\tan A = BC/AB = 1/\sqrt{3}$$

Let  $BC = 1k$  and  $AB = \sqrt{3}k$ ,

Where  $k$  is the positive real number of the problem

By Pythagoras theorem in  $\triangle ABC$  we get:

$$AC^2 = AB^2 + BC^2$$

$$AC^2 = (\sqrt{3}k)^2 + (k)^2$$

$$AC^2 = 3k^2 + k^2$$

$$AC^2 = 4k^2$$

$$AC = 2k$$

Now find the values of  $\cos A$ ,  $\sin A$

$$\sin A = BC/AC = 1/2$$

$$\cos A = AB/AC = \sqrt{3}/2$$

Then find the values of  $\cos C$  and  $\sin C$

$$\sin C = AB/AC = \sqrt{3}/2$$

$$\cos C = BC/AC = 1/2$$

Now, substitute the values in the given problem

$$(i) \sin A \cos C + \cos A \sin C = (1/2) \times (1/2) + \sqrt{3}/2 \times \sqrt{3}/2 = 1/4 + 3/4 = 1$$

$$(ii) \cos A \cos C - \sin A \sin C = (\sqrt{3}/2)(1/2) - (1/2)(\sqrt{3}/2) = 0$$

**10. In  $\triangle PQR$ , right-angled at Q,  $PR + QR = 25$  cm and  $PQ = 5$  cm. Determine the values of  $\sin P$ ,  $\cos P$  and  $\tan P$**

Solution:

In a given triangle PQR, right angled at Q, the following measures are

$$PQ = 5 \text{ cm}$$

$$PR + QR = 25 \text{ cm}$$

Now let us assume,  $QR = x$

$$PR = 25 - QR$$

$$PR = 25 - x$$

According to the Pythagorean Theorem,

$$PR^2 = PQ^2 + QR^2$$

Substitute the value of PR as x

$$(25 - x)^2 = 5^2 + x^2$$

$$25^2 + x^2 - 50x = 25 + x^2$$

$$625 + x^2 - 50x - 25 - x^2 = 0$$

$$-50x = -600$$

$$x = -600/-50$$

$$x = 12 = QR$$

Now, find the value of PR

$$PR = 25 - QR$$

Substitute the value of QR

$$PR = 25 - 12$$



$$PR = 13$$

Now, substitute the value to the given problem

$$(1) \sin p = \text{Opposite Side/Hypotenuse} = QR/PR = 12/13$$

$$(2) \cos p = \text{Adjacent Side/Hypotenuse} = PQ/PR = 5/13$$

$$(3) \tan p = \text{Opposite Side/Adjacent side} = QR/PQ = 12/5$$

**11. State whether the following are true or false. Justify your answer.**

**(i) The value of  $\tan A$  is always less than 1.**

**(ii)  $\sec A = 12/5$  for some value of angle  $A$ .**

**(iii)  $\cos A$  is the abbreviation used for the cosecant of angle  $A$ .**

**(iv)  $\cot A$  is the product of  $\cot$  and  $A$ .**

**(v)  $\sin \theta = 4/3$  for some angle  $\theta$ .**

Solution:

**(i)** The value of  $\tan A$  is always less than 1.

Answer: **False**

Proof: In  $\triangle MNC$  in which  $\angle N = 90^\circ$ ,

$$MN = 3, NC = 4 \text{ and } MC = 5$$

Value of  $\tan M = 4/3$  which is greater than 1.

The triangle can be formed with sides equal to 3, 4 and hypotenuse = 5 as it will follow the Pythagoras theorem.

$$MC^2 = MN^2 + NC^2$$

$$5^2 = 3^2 + 4^2$$

$$25 = 9 + 16$$

$$25 = 25$$

**(ii)**  $\sec A = 12/5$  for some value of angle  $A$

Answer: **True**

Justification: Let a  $\triangle MNC$  in which  $\angle N = 90^\circ$ ,

$MC = 12k$  and  $MB = 5k$ , where  $k$  is a positive real number.

By Pythagoras theorem we get,

$$MC^2 = MN^2 + NC^2$$

$$(12k)^2 = (5k)^2 + NC^2$$

$$NC^2 + 25k^2 = 144k^2$$

$$NC^2 = 119k^2$$

Such a triangle is possible as it will follow the Pythagoras theorem.

(iii)  $\cos A$  is the abbreviation used for the cosecant of angle A.

Answer: **False**

Justification: Abbreviation used for cosecant of angle M is  $\operatorname{cosec} M$ .  $\cos M$  is the abbreviation used for cosine of angle M.

(iv)  $\cot A$  is the product of  $\cot$  and A.

Answer: **False**

Justification:  $\cot M$  is not the product of  $\cot$  and M. It is the cotangent of  $\angle M$ .

(v)  $\sin \theta = 4/3$  for some angle  $\theta$ .

Answer: **False**

Justification:  $\sin \theta = \text{Opposite/Hypotenuse}$

We know that in a right angled triangle, Hypotenuse is the longest side.

$\therefore \sin \theta$  will always be less than 1 and it can never be  $4/3$  for any value of  $\theta$ .



## EXERCISE 8.2

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1. Evaluate the following:

(i)  $\sin 60^\circ \cos 30^\circ + \sin 30^\circ \cos 60^\circ$

(ii)  $2 \tan^2 45^\circ + \cos^2 30^\circ - \sin^2 60^\circ$

(iii)  $\frac{\cos 45^\circ}{\sec 30^\circ + \operatorname{cosec} 30^\circ}$

(iv)  $\frac{\sin 30^\circ + \tan 45^\circ - \operatorname{cosec} 60^\circ}{\sec 30^\circ + \cos 60^\circ + \cot 45^\circ}$

(v)  $\frac{5 \cos^2 60^\circ + 4 \sec^2 30^\circ - \tan^2 45^\circ}{\sin^2 30^\circ + \cos^2 30^\circ}$

Solution:

(i)  $\sin 60^\circ \cos 30^\circ + \sin 30^\circ \cos 60^\circ$

First, find the values of the given trigonometric ratios

$$\sin 30^\circ = 1/2$$

$$\cos 30^\circ = \sqrt{3}/2$$

$$\sin 60^\circ = 3/2$$

$$\cos 60^\circ = 1/2$$

Now, substitute the values in the given problem

$$\sin 60^\circ \cos 30^\circ + \sin 30^\circ \cos 60^\circ = \sqrt{3}/2 \times \sqrt{3}/2 + (1/2) \times (1/2) = 3/4 + 1/4 = 4/4 = 1$$

(ii)  $2 \tan^2 45^\circ + \cos^2 30^\circ - \sin^2 60^\circ$

We know that, the values of the trigonometric ratios are:

$$\sin 60^\circ = \sqrt{3}/2$$

$$\cos 30^\circ = \sqrt{3}/2$$

$$\tan 45^\circ = 1$$

Substitute the values in the given problem

$$2 \tan^2 45^\circ + \cos^2 30^\circ - \sin^2 60^\circ = 2(1)^2 + (\sqrt{3}/2)^2 - (\sqrt{3}/2)^2$$

$$2 \tan^2 45^\circ + \cos^2 30^\circ - \sin^2 60^\circ = 2 + 0$$

$$2 \tan^2 45^\circ + \cos^2 30^\circ - \sin^2 60^\circ = 2$$

(iii)  $\cos 45^\circ / (\sec 30^\circ + \operatorname{cosec} 30^\circ)$

We know that,

$$\cos 45^\circ = 1/\sqrt{2}$$

$$\sec 30^\circ = 2/\sqrt{3}$$

$$\operatorname{cosec} 30^\circ = 2$$

Substitute the values, we get

$$\begin{aligned}\frac{\cos 45^\circ}{\sec 30^\circ + \operatorname{cosec} 30^\circ} &= \frac{\frac{1}{\sqrt{2}}}{\frac{2}{\sqrt{3}} + 2} = \frac{\frac{1}{\sqrt{2}}}{\frac{2+2\sqrt{3}}{\sqrt{3}}} \\ &= \frac{1}{\sqrt{2}} \times \frac{\sqrt{3}}{2+2\sqrt{3}} \\ &= \frac{1}{\sqrt{2}} \times \frac{\sqrt{3}}{2(1+\sqrt{3})} = \frac{\sqrt{3}}{2\sqrt{2}(1+\sqrt{3})} = \frac{\sqrt{3}}{2\sqrt{2}(\sqrt{3}+1)}\end{aligned}$$

Now, rationalize the terms we get,

$$= \frac{\sqrt{3}}{2\sqrt{2}(\sqrt{3}+1)} \times \frac{\sqrt{3}-1}{\sqrt{3}-1} = \frac{3-\sqrt{3}}{2\sqrt{2}(3-1)} = \frac{3-\sqrt{3}}{2\sqrt{2}(2)}$$

Now, multiply both the numerator and denominator by  $\sqrt{2}$ , we get

$$= \frac{3-\sqrt{3}}{2\sqrt{2}(2)} \times \frac{\sqrt{2}}{\sqrt{2}} = \frac{3\sqrt{2}-\sqrt{3}\sqrt{2}}{8} = \frac{3\sqrt{2}-\sqrt{6}}{8}$$

Therefore,  $\cos 45^\circ / (\sec 30^\circ + \operatorname{cosec} 30^\circ) = (3\sqrt{2} - \sqrt{6})/8$

$$(iv) \frac{\sin 30^\circ + \tan 45^\circ - \operatorname{cosec} 60^\circ}{\sec 30^\circ + \cos 60^\circ + \cot 45^\circ}$$

We know that,

$$\sin 30^\circ = 1/2$$

$$\tan 45^\circ = 1$$

$$\operatorname{cosec} 60^\circ = 2/\sqrt{3}$$

$$\sec 30^\circ = 2/\sqrt{3}$$

$$\cos 60^\circ = 1/2$$

$$\cot 45^\circ = 1$$

Substitute the values in the given problem, we get

$$\frac{\sin 30^\circ + \tan 45^\circ - \operatorname{cosec} 60^\circ}{\sec 30^\circ + \cos 60^\circ + \cot 45^\circ} = \frac{\frac{1}{2} + 1 - \frac{2}{\sqrt{3}}}{\frac{2}{\sqrt{3}} + \frac{1}{2} + 1} = \frac{\frac{\sqrt{3} + 2\sqrt{3} - 4}{2\sqrt{3}}}{\frac{4 + \sqrt{3} + 2\sqrt{3}}{2\sqrt{3}}}$$

Now, cancel the term  $2\sqrt{3}$ , in numerator and denominator, we get

$$= \frac{\sqrt{3} + 2\sqrt{3} - 4}{4 + \sqrt{3} + 2\sqrt{3}} = \frac{3\sqrt{3} - 4}{3\sqrt{3} + 4}$$

Now, rationalize the terms

$$= \frac{3\sqrt{3} - 4}{3\sqrt{3} + 4} \times \frac{3\sqrt{3} - 4}{3\sqrt{3} - 4}$$

$$= \frac{27 - 12\sqrt{3} - 12\sqrt{3} + 16}{27 - 12\sqrt{3} + 12\sqrt{3} + 16} = \frac{27 - 24\sqrt{3} + 16}{11} = \frac{43 - 24\sqrt{3}}{11}$$

Therefore,

$$\frac{\sin 30^\circ + \tan 45^\circ - \operatorname{cosec} 60^\circ}{\sec 30^\circ + \cos 60^\circ + \cot 45^\circ} = \frac{43 - 24\sqrt{3}}{11}$$

$$(v) \frac{5 \cos^2 60^\circ + 4 \sec^2 30^\circ - \tan^2 45^\circ}{\sin^2 30^\circ + \cos^2 30^\circ}$$

We know that,

$$\cos 60^\circ = 1/2$$

$$\sec 30^\circ = 2/\sqrt{3}$$

$$\tan 45^\circ = 1$$

$$\sin 30^\circ = 1/2$$

$$\cos 30^\circ = \sqrt{3}/2$$

Now, substitute the values in the given problem, we get

$$(5 \cos^2 60^\circ + 4 \sec^2 30^\circ - \tan^2 45^\circ) / (\sin^2 30^\circ + \cos^2 30^\circ)$$

$$= 5(1/2)^2 + 4(2/\sqrt{3})^2 - 1^2 / ((1/2)^2 + (\sqrt{3}/2)^2)$$

$$= (5/4 + 16/3 - 1) / (1/4 + 3/4)$$

$$= (15 + 64 - 12) / 12 / (4/4)$$

$$= 67/12$$

2. Choose the correct option and justify your choice :

$$(i) 2 \tan 30^\circ / 1 + \tan^2 30^\circ =$$

$$(A) \sin 60^\circ \quad (B) \cos 60^\circ \quad (C) \tan 60^\circ \quad (D) \sin 30^\circ$$

$$(ii) 1 - \tan^2 45^\circ / 1 + \tan^2 45^\circ =$$

$$(A) \tan 90^\circ \quad (B) 1 \quad (C) \sin 45^\circ \quad (D) 0$$

$$(iii) \sin 2A = 2 \sin A \text{ is true when } A =$$

$$(A) 0^\circ \quad (B) 30^\circ \quad (C) 45^\circ \quad (D) 60^\circ$$

$$(iv) 2 \tan 30^\circ / 1 - \tan^2 30^\circ =$$

$$(A) \cos 60^\circ \quad (B) \sin 60^\circ \quad (C) \tan 60^\circ \quad (D) \sin 30^\circ$$

Solution:

(i) (A) is correct.

Substitute the of  $\tan 30^\circ$  in the given equation

$$\tan 30^\circ = 1/\sqrt{3}$$

$$2\tan 30^\circ/1+\tan^2 30^\circ = 2(1/\sqrt{3})/1+(1/\sqrt{3})^2$$

$$= (2/\sqrt{3})/(1+1/3) = (2/\sqrt{3})/(4/3)$$

$$= 6/4\sqrt{3} = \sqrt{3}/2 = \sin 60^\circ$$

The obtained solution is equivalent to the trigonometric ratio  $\sin 60^\circ$

(ii) (D) is correct.

Substitute the of  $\tan 45^\circ$  in the given equation

$$\tan 45^\circ = 1$$

$$1-\tan^2 45^\circ/1+\tan^2 45^\circ = (1-1^2)/(1+1^2)$$

$$= 0/2 = 0$$

The solution of the above equation is 0.

(iii) (A) is correct.

To find the value of A, substitute the degree given in the options one by one

$$\sin 2A = 2 \sin A \text{ is true when } A = 0^\circ$$

$$\text{As } \sin 2A = \sin 0^\circ = 0$$

$$2 \sin A = 2 \sin 0^\circ = 2 \times 0 = 0$$

or,

Apply the  $\sin 2A$  formula, to find the degree value

$$\sin 2A = 2 \sin A \cos A$$

$$\Rightarrow 2 \sin A \cos A = 2 \sin A$$

$$\Rightarrow 2 \cos A = 2 \Rightarrow \cos A = 1$$

Now, we have to check, to get the solution as 1, which degree value has to be applied.

When 0 degree is applied to cos value, i.e.,  $\cos 0 = 1$

Therefore,  $\Rightarrow A = 0^\circ$

(iv) (C) is correct.

Substitute the of  $\tan 30^\circ$  in the given equation

$$\tan 30^\circ = 1/\sqrt{3}$$

$$2\tan 30^\circ/1-\tan^2 30^\circ = 2(1/\sqrt{3})/1-(1/\sqrt{3})^2$$

$$= (2/\sqrt{3})/(1-1/3) = (2/\sqrt{3})/(2/3) = \sqrt{3} = \tan 60^\circ$$

The value of the given equation is equivalent to  $\tan 60^\circ$ .

3. If  $\tan (A + B) = \sqrt{3}$  and  $\tan (A - B) = 1/\sqrt{3}$ ,  $0^\circ < A + B \leq 90^\circ$ ;  $A > B$ , find A and B.

Solution:

$$\tan (A + B) = \sqrt{3}$$

$$\text{Since } \sqrt{3} = \tan 60^\circ$$

Now substitute the degree value

$$\Rightarrow \tan (A + B) = \tan 60^\circ$$

$$(A + B) = 60^\circ \dots (i)$$

The above equation is assumed as equation (i)

$$\tan (A - B) = 1/\sqrt{3}$$

$$\text{Since } 1/\sqrt{3} = \tan 30^\circ$$

Now substitute the degree value

$$\Rightarrow \tan (A - B) = \tan 30^\circ$$

$$(A - B) = 30^\circ \dots \text{equation (ii)}$$

Now add the equation (i) and (ii), we get

$$A + B + A - B = 60^\circ + 30^\circ$$

Cancel the terms B

$$2A = 90^\circ$$

$$A = 45^\circ$$

Now, substitute the value of A in equation (i) to find the value of B

$$45^\circ + B = 60^\circ$$

$$B = 60^\circ - 45^\circ$$

$$B = 15^\circ$$

Therefore  $A = 45^\circ$  and  $B = 15^\circ$

4. State whether the following are true or false. Justify your answer.

(i)  $\sin (A + B) = \sin A + \sin B$ .

(ii) The value of  $\sin \theta$  increases as  $\theta$  increases.

(iii) The value of  $\cos \theta$  increases as  $\theta$  increases.

(iv)  $\sin \theta = \cos \theta$  for all values of  $\theta$ .

(v)  $\cot A$  is not defined for  $A = 0^\circ$ .

Solution:

(i) False.

Justification:

Let us take  $A = 30^\circ$  and  $B = 60^\circ$ , then

Substitute the values in the  $\sin (A + B)$  formula, we get

$$\sin (A + B) = \sin (30^\circ + 60^\circ) = \sin 90^\circ = 1 \text{ and,}$$

$$\sin A + \sin B = \sin 30^\circ + \sin 60^\circ$$

$$= 1/2 + \sqrt{3}/2 = 1 + \sqrt{3}/2$$

Since the values obtained are not equal, the solution is false.

(ii) True.

Justification:

According to the values obtained as per the unit circle, the values of  $\sin$  are:

$$\sin 0^\circ = 0$$

$$\sin 30^\circ = 1/2$$

$$\sin 45^\circ = 1/\sqrt{2}$$

$$\sin 60^\circ = \sqrt{3}/2$$

$$\sin 90^\circ = 1$$

Thus the value of  $\sin \theta$  increases as  $\theta$  increases. Hence, the statement is true

(iii) False.

According to the values obtained as per the unit circle, the values of  $\cos$  are:

$$\cos 0^\circ = 1$$

$$\cos 30^\circ = \sqrt{3}/2$$

$$\cos 45^\circ = 1/\sqrt{2}$$

$$\cos 60^\circ = 1/2$$

$$\cos 90^\circ = 0$$

Thus, the value of  $\cos \theta$  decreases as  $\theta$  increases. So, the statement given above is false.

(iv) False

$\sin \theta = \cos \theta$ , when a right triangle has 2 angles of  $(\pi/4)$ . Therefore, the above statement is false.

(v) True.

Since  $\cot$  function is the reciprocal of the  $\tan$  function, it is also written as:

$$\cot A = \cos A / \sin A$$

Now substitute  $A = 0^\circ$

$$\cot 0^\circ = \cos 0^\circ / \sin 0^\circ = 1/0 = \text{undefined.}$$

Hence, it is true



## EXERCISE 8.3

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## 1. Evaluate :

(i)  $\sin 18^\circ / \cos 72^\circ$

(ii)  $\tan 26^\circ / \cot 64^\circ$

(iii)  $\cos 48^\circ - \sin 42^\circ$

(iv)  $\operatorname{cosec} 31^\circ - \sec 59^\circ$

Solution:

(i)  $\sin 18^\circ / \cos 72^\circ$

To simplify this, convert the sin function into cos function

We know that,  $18^\circ$  is written as  $90^\circ - 18^\circ$ , which is equal to the  $\cos 72^\circ$ .

$$= \sin (90^\circ - 18^\circ) / \cos 72^\circ$$

Substitute the value, to simplify this equation

$$= \cos 72^\circ / \cos 72^\circ = 1$$

(ii)  $\tan 26^\circ / \cot 64^\circ$

To simplify this, convert the tan function into cot function

We know that,  $26^\circ$  is written as  $90^\circ - 26^\circ$ , which is equal to the  $\cot 64^\circ$ .

$$= \tan (90^\circ - 26^\circ) / \cot 64^\circ$$

Substitute the value, to simplify this equation

$$= \cot 64^\circ / \cot 64^\circ = 1$$

(iii)  $\cos 48^\circ - \sin 42^\circ$

To simplify this, convert the cos function into sin function

We know that,  $48^\circ$  is written as  $90^\circ - 42^\circ$ , which is equal to the  $\sin 42^\circ$ .

$$= \cos (90^\circ - 42^\circ) - \sin 42^\circ$$

Substitute the value, to simplify this equation

$$= \sin 42^\circ - \sin 42^\circ = 0$$

(iv)  $\operatorname{cosec} 31^\circ - \sec 59^\circ$

To simplify this, convert the cosec function into sec function

We know that,  $31^\circ$  is written as  $90^\circ - 59^\circ$ , which is equal to the  $\sec 59^\circ$ 

$$= \operatorname{cosec} (90^\circ - 59^\circ) - \sec 59^\circ$$

Substitute the value, to simplify this equation

$$= \sec 59^\circ - \sec 59^\circ = 0$$

## 2. Show that:

(i)  $\tan 48^\circ \tan 23^\circ \tan 42^\circ \tan 67^\circ = 1$

(ii)  $\cos 38^\circ \cos 52^\circ - \sin 38^\circ \sin 52^\circ = 0$

Solution:

(i)  $\tan 48^\circ \tan 23^\circ \tan 42^\circ \tan 67^\circ$

Simplify the given problem by converting some of the tan functions to the cot functions

We know that,  $\tan 48^\circ = \tan (90^\circ - 42^\circ) = \cot 42^\circ$

$\tan 23^\circ = \tan (90^\circ - 67^\circ) = \cot 67^\circ$

$= \tan (90^\circ - 42^\circ) \tan (90^\circ - 67^\circ) \tan 42^\circ \tan 67^\circ$

Substitute the values

$= \cot 42^\circ \cot 67^\circ \tan 42^\circ \tan 67^\circ$

$= (\cot 42^\circ \tan 42^\circ) (\cot 67^\circ \tan 67^\circ) = 1 \times 1 = 1$

(ii)  $\cos 38^\circ \cos 52^\circ - \sin 38^\circ \sin 52^\circ$

Simplify the given problem by converting some of the cos functions to the sin functions

We know that,

$\cos 38^\circ = \cos (90^\circ - 52^\circ) = \sin 52^\circ$

$\cos 52^\circ = \cos (90^\circ - 38^\circ) = \sin 38^\circ$

$= \cos (90^\circ - 52^\circ) \cos (90^\circ - 38^\circ) - \sin 38^\circ \sin 52^\circ$

Substitute the values

$= \sin 52^\circ \sin 38^\circ - \sin 38^\circ \sin 52^\circ = 0$

**3. If  $\tan 2A = \cot (A - 18^\circ)$ , where  $2A$  is an acute angle, find the value of  $A$ .**

Solution:

$\tan 2A = \cot (A - 18^\circ)$

We know that  $\tan 2A = \cot (90^\circ - 2A)$

Substitute the above equation in the given problem

$\Rightarrow \cot (90^\circ - 2A) = \cot (A - 18^\circ)$

Now, equate the angles,

$\Rightarrow 90^\circ - 2A = A - 18^\circ \Rightarrow 108^\circ = 3A$

$A = 108^\circ / 3$

Therefore, the value of  $A = 36^\circ$

**4. If  $\tan A = \cot B$ , prove that  $A + B = 90^\circ$ .**

Solution:

$\tan A = \cot B$

We know that  $\cot B = \tan (90^\circ - B)$

To prove  $A + B = 90^\circ$ , substitute the above equation in the given problem

$$\tan A = \tan (90^\circ - B)$$

$$A = 90^\circ - B$$

$$A + B = 90^\circ$$

Hence Proved.

**5. If  $\sec 4A = \operatorname{cosec} (A - 20^\circ)$ , where  $4A$  is an acute angle, find the value of  $A$ .**

Solution:

$$\sec 4A = \operatorname{cosec} (A - 20^\circ)$$

$$\text{We know that } \sec 4A = \operatorname{cosec} (90^\circ - 4A)$$

To find the value of  $A$ , substitute the above equation in the given problem

$$\operatorname{cosec} (90^\circ - 4A) = \operatorname{cosec} (A - 20^\circ)$$

Now, equate the angles

$$90^\circ - 4A = A - 20^\circ$$

$$110^\circ = 5A$$

$$A = 110^\circ / 5 = 22^\circ$$

Therefore, the value of  $A = 22^\circ$

**6. If  $A$ ,  $B$  and  $C$  are interior angles of a triangle  $ABC$ , then show that**

$$\sin (B+C/2) = \cos A/2$$

Solution:

We know that, for a given triangle, sum of all the interior angles of a triangle is equal to  $180^\circ$

$$A + B + C = 180^\circ \dots(1)$$

To find the value of  $(B+C)/2$ , simplify the equation (1)

$$\Rightarrow B + C = 180^\circ - A$$

$$\Rightarrow (B+C)/2 = (180^\circ - A)/2$$

$$\Rightarrow (B+C)/2 = (90^\circ - A/2)$$

Now, multiply both sides by sin functions, we get

$$\Rightarrow \sin (B+C)/2 = \sin (90^\circ - A/2)$$

Since  $\sin (90^\circ - A/2) = \cos A/2$ , the above equation is equal to

$$\sin (B+C)/2 = \cos A/2$$

Hence proved.

**7. Express  $\sin 67^\circ + \cos 75^\circ$  in terms of trigonometric ratios of angles between  $0^\circ$  and  $45^\circ$ .**

Solution:

Given:

$$\sin 67^\circ + \cos 75^\circ$$

In term of sin as cos function and cos as sin function, it can be written as follows

$$\sin 67^\circ = \sin (90^\circ - 23^\circ)$$

$$\cos 75^\circ = \cos (90^\circ - 15^\circ)$$

$$\text{So, } \sin 67^\circ + \cos 75^\circ = \sin (90^\circ - 23^\circ) + \cos (90^\circ - 15^\circ)$$

Now, simplify the above equation

$$= \cos 23^\circ + \sin 15^\circ$$

Therefore,  $\sin 67^\circ + \cos 75^\circ$  is also expressed as  $\cos 23^\circ + \sin 15^\circ$



## EXERCISE 8.4

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**1. Express the trigonometric ratios  $\sin A$ ,  $\sec A$  and  $\tan A$  in terms of  $\cot A$ .**

Solution:

To convert the given trigonometric ratios in terms of  $\cot$  functions, use trigonometric formulas

We know that,

$$\operatorname{cosec}^2 A - \cot^2 A = 1$$

$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$

Since  $\operatorname{cosec}$  function is the inverse of  $\sin$  function, it is written as

$$1/\sin^2 A = 1 + \cot^2 A$$

Now, rearrange the terms, it becomes

$$\sin^2 A = 1/(1 + \cot^2 A)$$

Now, take square roots on both sides, we get

$$\sin A = \pm 1/(\sqrt{1 + \cot^2 A})$$

The above equation defines the  $\sin$  function in terms of  $\cot$  functionNow, to express  $\sec$  function in terms of  $\cot$  function, use this formula

$$\sin^2 A = 1/(1 + \cot^2 A)$$

Now, represent the  $\sin$  function as  $\cos$  function

$$1 - \cos^2 A = 1/(1 + \cot^2 A)$$

Rearrange the terms,

$$\cos^2 A = 1 - 1/(1 + \cot^2 A)$$

$$\Rightarrow \cos^2 A = (1 - 1 + \cot^2 A)/(1 + \cot^2 A)$$

Since  $\sec$  function is the inverse of  $\cos$  function,

$$\Rightarrow 1/\sec^2 A = \cot^2 A/(1 + \cot^2 A)$$

Take the reciprocal and square roots on both sides, we get

$$\Rightarrow \sec A = \pm \sqrt{(1 + \cot^2 A)/\cot A}$$

Now, to express  $\tan$  function in terms of  $\cot$  function

$$\tan A = \sin A/\cos A \text{ and } \cot A = \cos A/\sin A$$

Since  $\cot$  function is the inverse of  $\tan$  function, it is rewritten as

$$\tan A = 1/\cot A$$

**2. Write all the other trigonometric ratios of  $\angle A$  in terms of  $\sec A$ .**

Solution:

Cos A function in terms of  $\sec A$ :

$$\sec A = 1/\cos A$$

$$\Rightarrow \cos A = 1/\sec A$$

sec A function in terms of sec A:

$$\cos^2 A + \sin^2 A = 1$$

Rearrange the terms

$$\sin^2 A = 1 - \cos^2 A$$

$$\sin^2 A = 1 - (1/\sec^2 A)$$

$$\sin^2 A = (\sec^2 A - 1)/\sec^2 A$$

$$\sin A = \pm \sqrt{(\sec^2 A - 1)}/\sec A$$

cosec A function in terms of sec A:

$$\sin A = 1/\csc A$$

$$\Rightarrow \csc A = 1/\sin A$$

$$\csc A = \pm \sec A / \sqrt{(\sec^2 A - 1)}$$

Now, tan A function in terms of sec A:

$$\sec^2 A - \tan^2 A = 1$$

Rearrange the terms

$$\Rightarrow \tan^2 A = \sec^2 A - 1$$

$$\tan A = \sqrt{(\sec^2 A - 1)}$$

cot A function in terms of sec A:

$$\tan A = 1/\cot A$$

$$\Rightarrow \cot A = 1/\tan A$$

$$\cot A = \pm 1/\sqrt{(\sec^2 A - 1)}$$

### 3. Evaluate:

(i)  $(\sin^2 63^\circ + \sin^2 27^\circ)/(\cos^2 17^\circ + \cos^2 73^\circ)$

(ii)  $\sin 25^\circ \cos 65^\circ + \cos 25^\circ \sin 65^\circ$

Solution:

(i)  $(\sin^2 63^\circ + \sin^2 27^\circ)/(\cos^2 17^\circ + \cos^2 73^\circ)$

To simplify this, convert some of the sin functions into cos functions and cos function into sin function and it becomes,

$$= [\sin^2(90^\circ - 27^\circ) + \sin^2 27^\circ] / [\cos^2(90^\circ - 73^\circ) + \cos^2 73^\circ]$$

$$= (\cos^2 27^\circ + \sin^2 27^\circ)/(\sin^2 27^\circ + \cos^2 73^\circ)$$

$$= 1/1 = 1 \quad (\text{since } \sin^2 A + \cos^2 A = 1)$$

Therefore,  $(\sin^2 63^\circ + \sin^2 27^\circ)/(\cos^2 17^\circ + \cos^2 73^\circ) = 1$

(ii)  $\sin 25^\circ \cos 65^\circ + \cos 25^\circ \sin 65^\circ$

To simplify this, convert some of the sin functions into cos functions and cos function into sin function and it becomes,

$$= \sin(90^\circ - 25^\circ) \cos 65^\circ + \cos(90^\circ - 65^\circ) \sin 65^\circ$$

$$= \cos 65^\circ \cos 65^\circ + \sin 65^\circ \sin 65^\circ$$

$$= \cos^2 65^\circ + \sin^2 65^\circ = 1 \text{ (since } \sin^2 A + \cos^2 A = 1 \text{)}$$

Therefore,  $\sin 25^\circ \cos 65^\circ + \cos 25^\circ \sin 65^\circ = 1$

**4. Choose the correct option. Justify your choice.**

(i)  $9 \sec^2 A - 9 \tan^2 A =$

(A) 1                      (B) 9                      (C) 8                      (D) 0

(ii)  $(1 + \tan \theta + \sec \theta) (1 + \cot \theta - \operatorname{cosec} \theta)$

(A) 0                      (B) 1                      (C) 2                      (D) - 1

(iii)  $(\sec A + \tan A) (1 - \sin A) =$

(A)  $\sec A$                       (B)  $\sin A$                       (C)  $\operatorname{cosec} A$                       (D)  $\cos A$

(iv)  $1 + \tan^2 A / 1 + \cot^2 A =$

(A)  $\sec^2 A$                       (B) -1                      (C)  $\cot^2 A$                       (D)  $\tan^2 A$

Solution:

(i) (B) is correct.

Justification:

Take 9 outside, and it becomes

$$9 \sec^2 A - 9 \tan^2 A$$

$$= 9 (\sec^2 A - \tan^2 A)$$

$$= 9 \times 1 = 9 \quad (\because \sec^2 A - \tan^2 A = 1)$$

Therefore,  $9 \sec^2 A - 9 \tan^2 A = 9$

(ii) (C) is correct

Justification:

$$(1 + \tan \theta + \sec \theta) (1 + \cot \theta - \operatorname{cosec} \theta)$$

We know that,  $\tan \theta = \sin \theta / \cos \theta$

$$\sec \theta = 1 / \cos \theta$$

$$\cot \theta = \cos \theta / \sin \theta$$

$$\operatorname{cosec} \theta = 1 / \sin \theta$$

Now, substitute the above values in the given problem, we get

$$= (1 + \sin \theta / \cos \theta + 1 / \cos \theta) (1 + \cos \theta / \sin \theta - 1 / \sin \theta)$$

Simplify the above equation,

$$= (\cos \theta + \sin \theta + 1) / \cos \theta \times (\sin \theta + \cos \theta - 1) / \sin \theta$$

$$\begin{aligned}
 &= (\cos \theta + \sin \theta)^2 - 1^2 / (\cos \theta \sin \theta) \\
 &= (\cos^2 \theta + \sin^2 \theta + 2 \cos \theta \sin \theta - 1) / (\cos \theta \sin \theta) \\
 &= (1 + 2 \cos \theta \sin \theta - 1) / (\cos \theta \sin \theta) \quad (\text{Since } \cos^2 \theta + \sin^2 \theta = 1) \\
 &= (2 \cos \theta \sin \theta) / (\cos \theta \sin \theta) = 2
 \end{aligned}$$

Therefore,  $(1 + \tan \theta + \sec \theta)(1 + \cot \theta - \operatorname{cosec} \theta) = 2$

(iii) (D) is correct.

Justification:

We know that,

$$\sec A = 1/\cos A$$

$$\tan A = \sin A / \cos A$$

Now, substitute the above values in the given problem, we get

$$\begin{aligned}
 &(\sec A + \tan A)(1 - \sin A) \\
 &= (1/\cos A + \sin A/\cos A)(1 - \sin A) \\
 &= (1 + \sin A/\cos A)(1 - \sin A) \\
 &= (1 - \sin^2 A)/\cos A \\
 &= \cos^2 A/\cos A = \cos A
 \end{aligned}$$

Therefore,  $(\sec A + \tan A)(1 - \sin A) = \cos A$

(iv) (D) is correct.

Justification:

We know that,

$$\tan^2 A = 1/\cot^2 A$$

Now, substitute this in the given problem, we get

$$\begin{aligned}
 &1 + \tan^2 A / 1 + \cot^2 A \\
 &= (1 + 1/\cot^2 A) / 1 + \cot^2 A \\
 &= (\cot^2 A + 1/\cot^2 A) \times (1/1 + \cot^2 A) \\
 &= 1/\cot^2 A = \tan^2 A
 \end{aligned}$$

$$\text{So, } 1 + \tan^2 A / 1 + \cot^2 A = \tan^2 A$$

**5. Prove the following identities, where the angles involved are acute angles for which the expressions are defined.**

(i)  $(\operatorname{cosec} \theta - \cot \theta)^2 = (1 - \cos \theta) / (1 + \cos \theta)$

(ii)  $\cos A / (1 + \sin A) + (1 + \sin A) / \cos A = 2 \sec A$

(iii)  $\tan \theta / (1 - \cot \theta) + \cot \theta / (1 - \tan \theta) = 1 + \sec \theta \operatorname{cosec} \theta$

[Hint : Write the expression in terms of  $\sin \theta$  and  $\cos \theta$ ]



(iv)  $(1 + \sec A)/\sec A = \sin^2 A/(1 - \cos A)$

[Hint : Simplify LHS and RHS separately]

(v)  $(\cos A - \sin A + 1)/(\cos A + \sin A - 1) = \operatorname{cosec} A + \cot A$ , using the identity  $\operatorname{cosec}^2 A = 1 + \cot^2 A$ .

(vi)  $\sqrt{\frac{1 + \sin A}{1 - \sin A}} = \sec A + \tan A$

(vii)  $(\sin \theta - 2\sin^3 \theta)/(2\cos^3 \theta - \cos \theta) = \tan \theta$

(viii)  $(\sin A + \operatorname{cosec} A)^2 + (\cos A + \sec A)^2 = 7 + \tan^2 A + \cot^2 A$

(ix)  $(\operatorname{cosec} A - \sin A)(\sec A - \cos A) = 1/(\tan A + \cot A)$

[Hint : Simplify LHS and RHS separately] (x)  $(1 + \tan^2 A/1 + \cot^2 A) = (1 - \tan A/1 - \cot A)^2 = \tan^2 A$

Solution:

(i)  $(\operatorname{cosec} \theta - \cot \theta)^2 = (1 - \cos \theta)/(1 + \cos \theta)$

To prove this, first take the Left-Hand side (L.H.S) of the given equation, to prove the Right Hand Side (R.H.S)

L.H.S. =  $(\operatorname{cosec} \theta - \cot \theta)^2$

The above equation is in the form of  $(a-b)^2$ , and expand it

Since  $(a-b)^2 = a^2 + b^2 - 2ab$

Here  $a = \operatorname{cosec} \theta$  and  $b = \cot \theta$

=  $(\operatorname{cosec}^2 \theta + \cot^2 \theta - 2\operatorname{cosec} \theta \cot \theta)$

Now, apply the corresponding inverse functions and equivalent ratios to simplify

=  $(1/\sin^2 \theta + \cos^2 \theta/\sin^2 \theta - 2\cos \theta/\sin^2 \theta)$

=  $(1 + \cos^2 \theta - 2\cos \theta)/(1 - \cos^2 \theta)$

=  $(1 - \cos \theta)^2/(1 - \cos \theta)(1 + \cos \theta)$

=  $(1 - \cos \theta)/(1 + \cos \theta) = \text{R.H.S.}$

Therefore,  $(\operatorname{cosec} \theta - \cot \theta)^2 = (1 - \cos \theta)/(1 + \cos \theta)$

Hence proved.

(ii)  $(\cos A/(1 + \sin A)) + ((1 + \sin A)/\cos A) = 2 \sec A$

Now, take the L.H.S of the given equation.

L.H.S. =  $(\cos A/(1 + \sin A)) + ((1 + \sin A)/\cos A)$

=  $[\cos^2 A + (1 + \sin A)^2]/(1 + \sin A)\cos A$

=  $(\cos^2 A + \sin^2 A + 1 + 2\sin A)/(1 + \sin A) \cos A$

Since  $\cos^2 A + \sin^2 A = 1$ , we can write it as

=  $(1 + 1 + 2\sin A)/(1 + \sin A) \cos A$

=  $(2 + 2\sin A)/(1 + \sin A)\cos A$

=  $2(1 + \sin A)/(1 + \sin A)\cos A$

$$= 2/\cos A = 2 \sec A = \text{R.H.S.}$$

$$\text{L.H.S.} = \text{R.H.S.}$$

$$(\cos A/(1+\sin A)) + ((1+\sin A)/\cos A) = 2 \sec A$$

Hence proved.

$$(iii) \tan \theta/(1-\cot \theta) + \cot \theta/(1-\tan \theta) = 1 + \sec \theta \operatorname{cosec} \theta$$

$$\text{L.H.S.} = \tan \theta/(1-\cot \theta) + \cot \theta/(1-\tan \theta)$$

We know that  $\tan \theta = \sin \theta / \cos \theta$

$$\cot \theta = \cos \theta / \sin \theta$$

Now, substitute it in the given equation, to convert it in a simplified form

$$= [(\sin \theta / \cos \theta) / (1 - (\cos \theta / \sin \theta))] + [(\cos \theta / \sin \theta) / (1 - (\sin \theta / \cos \theta))]$$

$$= [(\sin \theta / \cos \theta) / ((\sin \theta - \cos \theta) / \sin \theta)] + [(\cos \theta / \sin \theta) / ((\cos \theta - \sin \theta) / \cos \theta)]$$

$$= \sin^2 \theta / [\cos \theta (\sin \theta - \cos \theta)] + \cos^2 \theta / [\sin \theta (\cos \theta - \sin \theta)]$$

$$= \sin^2 \theta / [\cos \theta (\sin \theta - \cos \theta)] - \cos^2 \theta / [\sin \theta (\sin \theta - \cos \theta)]$$

$$= 1/(\sin \theta - \cos \theta) [(\sin^2 \theta / \cos \theta) - (\cos^2 \theta / \sin \theta)]$$

$$= 1/(\sin \theta - \cos \theta) \times [(\sin^3 \theta - \cos^3 \theta) / \sin \theta \cos \theta]$$

$$= [(\sin \theta - \cos \theta)(\sin^2 \theta + \sin \theta \cos \theta + \cos^2 \theta)] / [(\sin \theta - \cos \theta) \sin \theta \cos \theta]$$

$$= (1 + \sin \theta \cos \theta) / \sin \theta \cos \theta$$

$$= 1/\sin \theta \cos \theta + 1$$

$$= 1 + \sec \theta \operatorname{cosec} \theta = \text{R.H.S.}$$

Therefore, L.H.S. = R.H.S.

Hence proved

$$(iv) (1 + \sec A)/\sec A = \sin^2 A / (1 - \cos A)$$

First find the simplified form of L.H.S

$$\text{L.H.S.} = (1 + \sec A)/\sec A$$

Since secant function is the inverse function of cos function and it is written as

$$= (1 + 1/\cos A) / (1/\cos A)$$

$$= (\cos A + 1) / \cos A \times \cos A$$

$$\text{Therefore, } (1 + \sec A)/\sec A = \cos A + 1$$

$$\text{R.H.S.} = \sin^2 A / (1 - \cos A)$$

We know that  $\sin^2 A = (1 - \cos^2 A)$ , we get

$$= (1 - \cos^2 A) / (1 - \cos A)$$

$$= (1 - \cos A)(1 + \cos A) / (1 - \cos A)$$

$$\text{Therefore, } \sin^2 A / (1 - \cos A) = \cos A + 1$$

L.H.S. = R.H.S.

Hence proved

(v)  $(\cos A - \sin A + 1)/(\cos A + \sin A - 1) = \operatorname{cosec} A + \cot A$ , using the identity  $\operatorname{cosec}^2 A = 1 + \cot^2 A$ .

With the help of identity function,  $\operatorname{cosec}^2 A = 1 + \cot^2 A$ , let us prove the above equation.

L.H.S. =  $(\cos A - \sin A + 1)/(\cos A + \sin A - 1)$

Divide the numerator and denominator by  $\sin A$ , we get

$$= (\cos A - \sin A + 1)/\sin A / (\cos A + \sin A - 1)/\sin A$$

We know that  $\cos A/\sin A = \cot A$  and  $1/\sin A = \operatorname{cosec} A$

$$= (\cot A - 1 + \operatorname{cosec} A)/(\cot A + 1 - \operatorname{cosec} A)$$

$$= (\cot A - \operatorname{cosec}^2 A + \cot^2 A + \operatorname{cosec} A)/(\cot A + 1 - \operatorname{cosec} A) \text{ (using } \operatorname{cosec}^2 A - \cot^2 A = 1)$$

$$= [(\cot A + \operatorname{cosec} A) - (\operatorname{cosec}^2 A - \cot^2 A)]/(\cot A + 1 - \operatorname{cosec} A)$$

$$= [(\cot A + \operatorname{cosec} A) - (\operatorname{cosec} A + \cot A)(\operatorname{cosec} A - \cot A)]/(1 - \operatorname{cosec} A + \cot A)$$

$$= (\cot A + \operatorname{cosec} A)(1 - \operatorname{cosec} A + \cot A)/(1 - \operatorname{cosec} A + \cot A)$$

$$= \cot A + \operatorname{cosec} A = \text{R.H.S.}$$

Therefore,  $(\cos A - \sin A + 1)/(\cos A + \sin A - 1) = \operatorname{cosec} A + \cot A$

Hence Proved

$$(vi) \sqrt{\frac{1+\sin A}{1-\sin A}} = \sec A + \tan A$$

$$\text{L.H.S} = \sqrt{\frac{1+\sin A}{1-\sin A}}$$

First divide the numerator and denominator of L.H.S. by  $\cos A$ ,

$$= \sqrt{\frac{\frac{1}{\cos A} + \frac{\sin A}{\cos A}}{\frac{1}{\cos A} - \frac{\sin A}{\cos A}}}$$

We know that  $1/\cos A = \sec A$  and  $\sin A/\cos A = \tan A$  and it becomes,

$$= \sqrt{(\sec A + \tan A)/(\sec A - \tan A)}$$

Now using rationalization, we get

$$= \sqrt{\frac{\sec A + \tan A}{\sec A - \tan A}} \times \sqrt{\frac{\sec A + \tan A}{\sec A + \tan A}}$$

$$= \sqrt{\frac{(\sec A + \tan A)^2}{\sec^2 A - \tan^2 A}}$$

$$= (\sec A + \tan A)/1$$

$$= \sec A + \tan A = \text{R.H.S}$$

Hence proved

$$(vii) (\sin \theta - 2\sin^3 \theta)/(2\cos^3 \theta - \cos \theta) = \tan \theta$$

$$\text{L.H.S.} = (\sin \theta - 2\sin^3 \theta)/(2\cos^3 \theta - \cos \theta)$$

Take  $\sin \theta$  as in numerator and  $\cos \theta$  in denominator as outside, it becomes

$$= [\sin \theta(1 - 2\sin^2 \theta)]/[\cos \theta(2\cos^2 \theta - 1)]$$

We know that  $\sin^2 \theta = 1 - \cos^2 \theta$

$$= \sin \theta[1 - 2(1 - \cos^2 \theta)]/[\cos \theta(2\cos^2 \theta - 1)]$$

$$= [\sin \theta(2\cos^2 \theta - 1)]/[\cos \theta(2\cos^2 \theta - 1)]$$

$$= \tan \theta = \text{R.H.S.}$$

Hence proved

$$(viii) (\sin A + \operatorname{cosec} A)^2 + (\cos A + \sec A)^2 = 7 + \tan^2 A + \cot^2 A$$

$$\text{L.H.S.} = (\sin A + \operatorname{cosec} A)^2 + (\cos A + \sec A)^2$$

It is of the form  $(a+b)^2$ , expand it

$$(a+b)^2 = a^2 + b^2 + 2ab$$

$$= (\sin^2 A + \operatorname{cosec}^2 A + 2 \sin A \operatorname{cosec} A) + (\cos^2 A + \sec^2 A + 2 \cos A \sec A)$$

$$= (\sin^2 A + \cos^2 A) + 2 \sin A(1/\sin A) + 2 \cos A(1/\cos A) + 1 + \tan^2 A + 1 + \cot^2 A$$

$$= 1 + 2 + 2 + 2 + \tan^2 A + \cot^2 A$$

$$= 7 + \tan^2 A + \cot^2 A = \text{R.H.S.}$$

$$\text{Therefore, } (\sin A + \operatorname{cosec} A)^2 + (\cos A + \sec A)^2 = 7 + \tan^2 A + \cot^2 A$$

Hence proved.

$$(ix) (\operatorname{cosec} A - \sin A)(\sec A - \cos A) = 1/(\tan A + \cot A)$$

First, find the simplified form of L.H.S

$$\text{L.H.S.} = (\operatorname{cosec} A - \sin A)(\sec A - \cos A)$$

Now, substitute the inverse and equivalent trigonometric ratio forms

$$= (1/\sin A - \sin A)(1/\cos A - \cos A)$$

$$= [(1-\sin^2 A)/\sin A][(1-\cos^2 A)/\cos A]$$

$$= (\cos^2 A/\sin A) \times (\sin^2 A/\cos A)$$

$$= \cos A \sin A$$

Now, simplify the R.H.S

$$\text{R.H.S.} = 1/(\tan A + \cot A)$$

$$= 1/(\sin A/\cos A + \cos A/\sin A)$$

$$= 1/[(\sin^2 A + \cos^2 A)/\sin A \cos A]$$

$$= \cos A \sin A$$

$$\text{L.H.S.} = \text{R.H.S.}$$

$$(\operatorname{cosec} A - \sin A)(\sec A - \cos A) = 1/(\tan A + \cot A)$$

Hence proved

$$(x) \quad (1 + \tan^2 A / 1 + \cot^2 A) = (1 - \tan A / 1 - \cot A)^2 = \tan^2 A$$

$$\text{L.H.S.} = (1 + \tan^2 A / 1 + \cot^2 A)$$

Since cot function is the inverse of tan function,

$$= (1 + \tan^2 A / 1 + 1/\tan^2 A)$$

$$= 1 + \tan^2 A / [(1 + \tan^2 A) / \tan^2 A]$$

Now cancel the  $1 + \tan^2 A$  terms, we get

$$= \tan^2 A$$

$$(1 + \tan^2 A / 1 + \cot^2 A) = \tan^2 A$$

Similarly,

$$(1 - \tan A / 1 - \cot A)^2 = \tan^2 A$$

Hence proved

