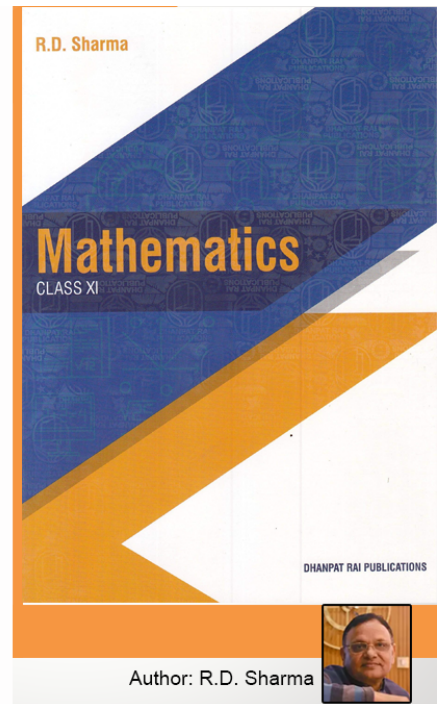


Class 11 - Chapter 10 Sine and Cosine Formulae and their Applications



RD Sharma Solutions for Class 11 Maths Chapter 10–Sine and Cosine Formulae and their Applications

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RD Sharma 11th Maths Chapter 10, Class 11 Maths Chapter 10 solutions

EXERCISE 10.1 PAGE NO: 10.12

1. If in a $\triangle ABC$, $\angle A = 45^\circ$, $\angle B = 60^\circ$, and $\angle C = 75^\circ$; find the ratio of its sides.

Solution:

Given: In $\triangle ABC$, $\angle A = 45^\circ$, $\angle B = 60^\circ$, and $\angle C = 75^\circ$

By using the sine rule, we get

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

Now by substituting the values we get,

$$\frac{a}{\sin 45^\circ} = \frac{b}{\sin 60^\circ} = \frac{c}{\sin 75^\circ}$$

$$\frac{a}{\sin 45^\circ} = \frac{b}{\sin 60^\circ} = \frac{c}{\sin(30^\circ + 45^\circ)}$$

$$\frac{a}{\sin 45^\circ} = \frac{b}{\sin 60^\circ} = \frac{c}{\sin 30^\circ \cos 45^\circ + \sin 45^\circ \cos 30^\circ}$$

We know, $\sin(a + b) = \sin a \cos b + \sin b \cos a$

Now by substituting the corresponding values, we get,

$$\frac{a}{\frac{1}{\sqrt{2}}} = \frac{b}{\frac{\sqrt{3}}{2}} = \frac{c}{\frac{1}{2} \times \frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}} \times \frac{\sqrt{3}}{2}}$$

$$\frac{a}{\frac{1}{\sqrt{2}}} = \frac{b}{\frac{\sqrt{3}}{2}} = \frac{c}{\frac{1 + \sqrt{3}}{2\sqrt{2}}}$$

$$a : b : c = \frac{1}{\sqrt{2}} : \frac{\sqrt{3}}{2} : \frac{1 + \sqrt{3}}{2\sqrt{2}}$$

Multiply the above expression by $2\sqrt{2}$, we get

$$a : b : c = 2 : \sqrt{6} : (1 + \sqrt{3})$$

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Hence the ratio of the sides of the given triangle is $a : b : c = 2 : \sqrt{6} : (1 + \sqrt{3})$

2. If in any $\triangle ABC$, $\angle C = 105^\circ$, $\angle B = 45^\circ$, $a = 2$, then find b .

Solution:

Given: In $\triangle ABC$, $\angle C = 105^\circ$, $\angle B = 45^\circ$, $a = 2$

We know in a triangle,

$$\angle A + \angle B + \angle C = 180^\circ$$

$$\angle A = 180^\circ - \angle B - \angle C$$

Substituting the given values, we get

$$\angle A = 180^\circ - 45^\circ - 105^\circ$$

$$\angle A = 30^\circ$$

By using the sine rule, we get

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$\frac{a}{\sin A} = \frac{b}{\sin B}$$

Now by substituting the corresponding values we get,

$$\frac{2}{\sin 30^\circ} = \frac{b}{\sin 45^\circ}$$

Substitute the equivalent values of the sine, we get

$$\frac{2}{1} = \frac{b}{\frac{1}{\sqrt{2}}}$$

$$4 = b\sqrt{2}$$

$$b = \frac{4}{\sqrt{2}}$$

$$= 2\sqrt{2}$$

Hence the value of b is $2\sqrt{2}$ units.

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3. In $\triangle ABC$, if $a = 18$, $b = 24$ and $c = 30$ and $\angle C = 90^\circ$, find $\sin A$, $\sin B$ and $\sin C$.

Solution:

Given: In $\triangle ABC$, $a = 18$, $b = 24$ and $c = 30$ and $\angle C = 90^\circ$

By using the sine rule, we get

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$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$\frac{a}{\sin A} = \frac{c}{\sin C}$$

Now by substituting the given values we get,

$$\frac{18}{\sin A} = \frac{30}{\sin 90^\circ}$$

$$\sin A = \frac{18 \times \sin 90^\circ}{30}$$

$$\sin A = \frac{18 \times 1}{30}$$

$$\sin A = \frac{3}{5}$$

Similarly,

$$\frac{b}{\sin B} = \frac{c}{\sin C}$$

Substitute the given values, we get

$$\frac{24}{\sin B} = \frac{30}{\sin 90^\circ}$$

$$\sin B = \frac{24 \times \sin 90^\circ}{30}$$

$$\sin B = \frac{24 \times 1}{30}$$

$$\sin B = \frac{4}{5}$$

And given, $\angle C = 90^\circ$, so $\sin C = \sin 90^\circ = 1$.

Hence the values of $\sin A = 3/5$, $\sin B = 4/5$ and $\sin C = 1$ respectively.

In any triangle ABC, prove the following:

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$$4. \frac{a - b}{a + b} = \frac{\tan \left(\frac{A-B}{2} \right)}{\tan \left(\frac{A+B}{2} \right)}$$

Solution:

By using the sine rule we know,

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$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = k$$

$$\frac{a}{\sin A} = k$$

$$\text{So, } a = k \sin A$$

$$\text{Similarly, } b = k \sin B$$

$$\text{And } c = k \sin C$$

We know,

$$a - b = k (\sin A - \sin B)$$

$$a + b = k (\sin A + \sin B)$$

Now let us consider LHS:

$$\begin{aligned}\frac{a-b}{a+b} &= \frac{k(\sin A - \sin B)}{k(\sin A + \sin B)} \\ &= \frac{(\sin A - \sin B)}{(\sin A + \sin B)} \dots (i)\end{aligned}$$

We know,

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

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

Substituting the above formulas in equation (i), we get

$$\frac{a-b}{a+b} = \frac{\left(2 \sin \left(\frac{A-B}{2}\right) \cos \left(\frac{A+B}{2}\right)\right)}{\left(2 \sin \left(\frac{A+B}{2}\right) \cos \left(\frac{A-B}{2}\right)\right)}$$

Upon rearranging we get,

$$\begin{aligned}&= \frac{\left(\sin \left(\frac{A-B}{2}\right)\right)}{\left(\cos \left(\frac{A-B}{2}\right)\right)} \times \frac{\cos \left(\frac{A+B}{2}\right)}{\sin \left(\frac{A+B}{2}\right)} \\ &= \frac{\left(\tan \left(\frac{A-B}{2}\right)\right)}{1} \times \frac{1}{\tan \left(\frac{A+B}{2}\right)} \\ &= \frac{\left(\tan \left(\frac{A-B}{2}\right)\right)}{\left(\tan \left(\frac{A+B}{2}\right)\right)}\end{aligned}$$

= RHS

Hence proved.

$$5. (a-b) \cos C/2 = C \sin (A-B)/2$$

Solution:

By using the sine rule we know,

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$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = k$$

$$\frac{a}{\sin A} = k$$

$$\text{So, } a = k \sin A$$

$$\text{Similarly, } b = k \sin B$$

We know,

$$a - b = k (\sin A - \sin B) \dots (i)$$

Now let us consider LHS:

$$(a - b) \cos \frac{C}{2}$$

Substituting equation (i) in above equation, we get

$$(k(\sin A - \sin B)) \cos \frac{C}{2} \dots (ii)$$

We know,

$$\sin A - \sin B = 2 \sin \frac{(A-B)}{2} \cos \frac{(A+B)}{2}$$

Substituting the above formulas in equation (ii), we get

$$\begin{aligned} (a - b) \cos \frac{C}{2} &= \left(k \left(2 \sin \left(\frac{A-B}{2} \right) \cos \left(\frac{A+B}{2} \right) \right) \right) \cos \frac{C}{2} \\ &= \left(k \left(2 \sin \left(\frac{A-B}{2} \right) \cos \left(\frac{A+B}{2} \right) \right) \right) \cos \frac{(\pi - (A+B))}{2} \\ &= \left(2k \sin \left(\frac{A-B}{2} \right) \cos \left(\frac{A+B}{2} \right) \right) \sin \left(\frac{A+B}{2} \right) \quad [\text{since, } \cos(\pi/2 - A) = \sin A] \end{aligned}$$

Upon rearranging we get,

$$= k \sin \left(\frac{A-B}{2} \right) \left(2 \sin \left(\frac{A+B}{2} \right) \cos \left(\frac{A+B}{2} \right) \right)$$

$$\text{We know, } \sin A = 2 \cos (A/2) \sin (A/2)$$

So the above equation becomes,

$$\begin{aligned} &= k \sin\left(\frac{A-B}{2}\right) (\sin(A+B)) \\ &= k \sin\left(\frac{A-B}{2}\right) (\sin(\pi-C)) \quad [\text{since, } \pi = A+B+C, \text{ where, } A+B = \pi-C] \\ &= k \sin(C) \sin\left(\frac{A-B}{2}\right) \quad [\text{since, } \sin(\pi-A) = \sin A] \end{aligned}$$

From the sine rule,

$$\frac{c}{\sin C} = k \Rightarrow c = k \sin C$$

So the above equation becomes,

$$= c \sin\left(\frac{A-B}{2}\right)$$

= RHS

Hence proved.

$$6. \frac{c}{a-b} = \frac{\tan\left(\frac{A}{2}\right) + \tan\left(\frac{B}{2}\right)}{\tan\left(\frac{A}{2}\right) - \tan\left(\frac{B}{2}\right)}$$

Solution:

By using the sine rule we know,

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = k$$

$$\frac{a}{\sin A} = k$$

So, $a = k \sin A$

Similarly, $b = k \sin B$

And $c = k \sin C \dots$ (i)

We know,

$$a - b = k (\sin A - \sin B) \dots (ii)$$

Now let us consider LHS:

$$\frac{c}{a - b}$$

Substituting equation (i) and (ii) in above equation, we get

$$\frac{k \sin C}{k(\sin A - \sin B)} = \frac{\sin C}{(\sin A - \sin B)} \dots (iii)$$

By applying half angle rule,

$$\sin C = 2 \sin \frac{C}{2} \cos \frac{C}{2} \dots (iv)$$

And we know,

$$\sin A - \sin B = 2 \sin \frac{(A-B)}{2} \cos \frac{(A+B)}{2} \dots (v)$$

Substituting the above equations (iv) and (v) in equation (iii), we get

$$\begin{aligned} \frac{c}{(a - b)} &= \frac{2 \sin \frac{C}{2} \cos \frac{C}{2}}{2 \sin \left(\frac{A - B}{2} \right) \cos \left(\frac{A + B}{2} \right)} \\ &= \frac{\sin \left(\frac{\pi - (A + B)}{2} \right) \cos \left(\frac{C}{2} \right)}{\sin \left(\frac{A - B}{2} \right) \cos \left(\frac{A + B}{2} \right)} \quad [\text{since, } \pi = A+B+C, \text{ where, } C = \pi - (A+B)] \end{aligned}$$

$$= \frac{\cos\left(\frac{A+B}{2}\right)\cos\left(\frac{C}{2}\right)}{\sin\left(\frac{A-B}{2}\right)\cos\left(\frac{A+B}{2}\right)} \quad [\text{since, } \sin(\pi/2 - A) = \cos A]$$

Upon simplification we get,

$$\begin{aligned} &= \frac{\cos\left(\frac{C}{2}\right)}{\sin\left(\frac{A-B}{2}\right)} \\ &= \frac{\cos\left(\frac{\pi - (A+B)}{2}\right)}{\sin\left(\frac{A-B}{2}\right)} \quad [\text{since, } \pi = A+B+C, \text{ where, } C = \pi - (A+B)] \\ &= \frac{\sin\left(\frac{(A+B)}{2}\right)}{\sin\left(\frac{A-B}{2}\right)} \quad \dots \text{(vi)} \quad [\text{since, } \cos(\pi/2 - A) = \sin A] \end{aligned}$$

We know,

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

$$\sin(A-B)/2 = \sin(A/2 - B/2) = \sin A/2 \cos B/2 - \cos A/2 \sin B/2$$

Substituting the above equations in equation (vi) we get,

$$= \frac{\sin \frac{A}{2} \cos \frac{B}{2} + \cos \left(\frac{A}{2}\right) \sin \left(\frac{B}{2}\right)}{\sin \frac{A}{2} \cos \frac{B}{2} - \cos \left(\frac{A}{2}\right) \sin \left(\frac{B}{2}\right)}$$

Let us divide the numerator and denominator by $\cos A/2 \cos B/2$, we get

$$\begin{aligned}
 & \frac{\sin \frac{A}{2} \cos \frac{B}{2} + \cos \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2}} \\
 = & \frac{\sin \frac{A}{2} \cos \frac{B}{2} - \cos \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2}} \\
 & \frac{\sin \frac{A}{2} \cos \frac{B}{2}}{\cos \frac{A}{2} \cos \frac{B}{2}} + \frac{\cos \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2}} \\
 = & \frac{\sin \frac{A}{2} \cos \frac{B}{2}}{\cos \frac{A}{2} \cos \frac{B}{2}} - \frac{\cos \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2}} \\
 & \frac{\sin \frac{A}{2} \cos \frac{B}{2}}{\cos \frac{A}{2} \cos \frac{B}{2}} + \frac{\cos \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2}} \\
 = & \frac{\sin \frac{A}{2}}{\cos \frac{A}{2}} + \frac{\sin \left(\frac{B}{2} \right)}{\cos \frac{B}{2}} \\
 & \frac{\sin \frac{A}{2}}{\cos \frac{A}{2}} - \frac{\sin \left(\frac{B}{2} \right)}{\cos \frac{B}{2}} \\
 = & \frac{\tan \frac{A}{2} + \tan \frac{B}{2}}{\tan \frac{A}{2} - \tan \frac{B}{2}} \\
 & = \text{RHS}
 \end{aligned}$$

Upon simplification we get,

Hence proved.

$$7. \frac{c}{a+b} = \frac{1 - \tan \left(\frac{A}{2} \right) \tan \left(\frac{B}{2} \right)}{1 + \tan \left(\frac{A}{2} \right) \tan \left(\frac{B}{2} \right)}$$

Solution:

By using the sine rule we know,

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = k$$

$$\frac{a}{\sin A} = k$$

So, $a = k \sin A$

Similarly, $b = k \sin B$

And $c = k \sin C \dots (i)$

We know,

$$a + b = k (\sin A + \sin B) \dots (ii)$$

Now let us consider LHS:

$$\frac{c}{a + b}$$

Substituting equation (i) and (ii) in above equation, we get

$$\frac{k \sin C}{k(\sin A + \sin B)} = \frac{\sin C}{(\sin A + \sin B)} \dots (iii)$$

By applying half angle rule,

$$\sin C = 2 \sin \frac{C}{2} \cos \frac{C}{2} \dots (iv)$$

And we know,

$$\sin A + \sin B = 2 \sin \frac{(A+B)}{2} \cos \frac{(A-B)}{2} \dots (v)$$

Substituting the above equations (iv) and (v) in equation (iii), we get

$$\begin{aligned} \frac{c}{(a+b)} &= \frac{2 \sin \frac{C}{2} \cos \frac{C}{2}}{2 \sin \left(\frac{A+B}{2} \right) \cos \left(\frac{A-B}{2} \right)} \\ &= \frac{\sin \left(\frac{\pi - (A+B)}{2} \right) \cos \left(\frac{\pi - (A+B)}{2} \right)}{\sin \left(\frac{A+B}{2} \right) \cos \left(\frac{A-B}{2} \right)} \end{aligned}$$

[Since, $\pi = A+B+C$, where,

$$\begin{aligned} C &= \pi - (A+B) \\ &= \frac{\cos \left(\frac{A+B}{2} \right) \sin \left(\frac{A+B}{2} \right)}{\sin \left(\frac{A+B}{2} \right) \cos \left(\frac{A-B}{2} \right)} \end{aligned}$$

[Since, $\sin (\pi/2 - A) = \cos A$, $\cos (\pi/2 - A) = \sin A$]

Upon simplification we get,

$$= \frac{\cos \left(\frac{(A+B)}{2} \right)}{\cos \left(\frac{A-B}{2} \right)} \dots (vi)$$

We know,

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

$$\cos (A-B)/2 = \cos (A/2 - B/2) = \cos A/2 \cos B/2 - \sin A/2 \sin B/2$$

Substituting the above equations in equation (vi) we get,

$$= \frac{\cos \frac{A}{2} \cos \frac{B}{2} + \sin \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2} - \sin \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}$$

Let us divide the numerator and denominator by $\cos \frac{A}{2} \cos \frac{B}{2}$, we get

$$\begin{aligned} & \frac{\cos \frac{A}{2} \cos \frac{B}{2} + \sin \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2}} \\ &= \frac{\cos \frac{A}{2} \cos \frac{B}{2} + \sin \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2} - \sin \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)} \\ &= \frac{\frac{\cos \frac{A}{2} \cos \frac{B}{2}}{\cos \frac{A}{2} \cos \frac{B}{2}} + \frac{\sin \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2}}}{\frac{\cos \frac{A}{2} \cos \frac{B}{2}}{\cos \frac{A}{2} \cos \frac{B}{2}} - \frac{\sin \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2}}} \end{aligned}$$

Upon simplification we get,

$$\begin{aligned} & 1 + \frac{\sin \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2}} \\ &= \frac{1 + \frac{\sin \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2}}}{1 - \frac{\sin \left(\frac{A}{2} \right) \sin \left(\frac{B}{2} \right)}{\cos \frac{A}{2} \cos \frac{B}{2}}} \\ &= \frac{1 + \tan \frac{A}{2} \tan \frac{B}{2}}{1 - \tan \frac{A}{2} \tan \frac{B}{2}} \\ &= \text{RHS} \end{aligned}$$

Hence proved.

$$8. \frac{a+b}{c} = \frac{\cos \left(\frac{A-B}{2} \right)}{\sin \frac{C}{2}}$$

Solution:

By using the sine rule we know,

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$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = k$$

$$\frac{a}{\sin A} = k$$

So, $a = k \sin A$

Similarly, $b = k \sin B$

And $c = k \sin C \dots (i)$

We know,

$$a + b = k (\sin A + \sin B) \dots (ii)$$

Now let us consider LHS:

$$\frac{a + b}{c}$$

Substituting equation (i) and (ii) in above equation, we get

$$\frac{k(\sin A + \sin B)}{k(\sin C)} = \frac{(\sin A + \sin B)}{(\sin C)} \dots (iii)$$

By applying half angle rule,

$$\sin C = 2 \sin \frac{C}{2} \cos \frac{C}{2} \dots (iv)$$

And we know,

$$\sin A + \sin B = 2 \sin \frac{(A+B)}{2} \cos \frac{(A-B)}{2} \dots (v)$$

Substituting the above equations (iv) and (v) in equation (iii), we get

$$\begin{aligned} \frac{a + b}{c} &= \frac{2 \sin \left(\frac{A + B}{2} \right) \cos \left(\frac{A - B}{2} \right)}{2 \sin \left(\frac{C}{2} \right) \cos \left(\frac{C}{2} \right)} \\ &= \frac{\sin \left(\frac{A + B}{2} \right) \cos \left(\frac{A - B}{2} \right)}{\sin \left(\frac{C}{2} \right) \cos \left(\frac{\pi - (A + B)}{2} \right)} \quad [\text{Since, } \pi = A+B+C, \text{ where, } C = \pi - (A+B)] \end{aligned}$$

$$= \frac{\sin\left(\frac{A+B}{2}\right) \cos\left(\frac{A-B}{2}\right)}{\sin\left(\frac{C}{2}\right) \sin\left(\frac{A+B}{2}\right)} \quad [\text{Since, } \sin(\pi/2 - A) = \cos A, \cos(\pi/2 - A) = \sin A]$$

A]

Upon simplification we get,

$$= \frac{\cos\left(\frac{A-B}{2}\right)}{\sin\left(\frac{C}{2}\right)}$$

= RHS

Hence proved.

$$9. \sin\left(\frac{B-C}{2}\right) = \frac{b-c}{a} \cos\frac{A}{2}$$

Solution:

By using the sine rule we know,

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = k$$

$$\frac{c}{\sin C} = k$$

So, $c = k \sin C$

Similarly, $b = k \sin B$

We know,

$$b - c = k (\sin B - \sin C) \dots (i)$$

Now let us consider RHS:

$$\frac{b - c}{a} \cos \frac{A}{2}$$

Substituting equation (i) in above equation, we get

$$\frac{(k(\sin B - \sin C))}{k \sin A} \cos \frac{A}{2} = \frac{(\sin B - \sin C)}{\sin A} \cos \frac{A}{2} \dots (ii)$$

And we know,

$$\sin B - \sin C = 2 \sin \frac{(B-C)}{2} \cos \frac{(B+C)}{2} \dots (iii)$$

Substituting the above equation (iii) in equation (ii), we get

$$\frac{b - c}{a} \cos \frac{A}{2} = \frac{2 \sin \left(\frac{B-C}{2} \right) \cos \left(\frac{B+C}{2} \right)}{\sin A} \cos \left(\frac{\pi - (B+C)}{2} \right) \quad [\text{Since, } \pi =$$

$A+B+C$, where, $C = \pi - (A+B)$]

$$= \frac{2 \sin\left(\frac{B-C}{2}\right) \cos\left(\frac{B+C}{2}\right)}{\sin A} \sin\left(\frac{(B+C)}{2}\right) \quad [\text{Since, } \cos(\pi/2 - A)]$$

= sin A]

Upon rearranging the above equation we get,

$$= \frac{\sin\left(\frac{B-C}{2}\right) \left(2 \sin\left(\frac{(B+C)}{2}\right) \cos\left(\frac{(B+C)}{2}\right)\right)}{\sin A}$$

We know $\sin A = 2 \cos(A/2) \sin(A/2)$

So,

$$\begin{aligned} &= \frac{\sin\left(\frac{B-C}{2}\right) (\sin(B+C))}{\sin A} \\ &= \frac{\sin\left(\frac{B-C}{2}\right) (\sin(\pi - A))}{\sin A} \quad [\text{Since, } \pi = A+B+C, \text{ where, } A+B = \pi-C] \\ &= \frac{\sin\left(\frac{B-C}{2}\right) \sin A}{\sin A} \quad [\text{Since, } \sin(\pi-A) = \sin A] \end{aligned}$$

Upon simplification we get,

$$\begin{aligned} &= \sin\left(\frac{B-C}{2}\right) \\ &= \text{LHS} \end{aligned}$$

Hence proved.

$$10. \frac{a^2 - c^2}{b^2} = \frac{\sin(A - C)}{\sin(A + C)}$$

Solution:

By using the sine rule we know,

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = k$$

$$\frac{c}{\sin C} = k$$

$$\text{So, } c = k \sin C$$

$$\text{Similarly, } a = k \sin A$$

$$\text{And } b = k \sin B$$

$$\text{So, } a - c = k (\sin A - \sin C) \dots (i)$$

We know,

Now let us consider LHS:

$$\frac{a^2 - c^2}{b^2}$$

Substituting the values in the above equation, we get

$$\frac{(k \sin A)^2 - (k \sin C)^2}{(k \sin B)^2} = \frac{k^2 (\sin^2 A - \sin^2 C)}{k^2 \sin^2 B} \dots (ii)$$

And we know,

$$\sin^2 A - \sin^2 C = \sin(A + C) \sin(A - C) \dots (iii)$$

Substituting the above equation (iii) in equation (ii), we get

$$\begin{aligned}\frac{a^2 - c^2}{b^2} &= \frac{\sin(A + C) \sin(A - C)}{\sin^2(\pi - (A + C))} \quad [\text{Since, } \pi = A+B+C, \text{ where, } C = \pi - (A+B)] \\ &= \frac{\sin(A + C) \sin(A - C)}{\sin^2((A + C))} \quad [\text{Since, } \sin(\pi - A) = \sin A] \\ &= \frac{\sin(A - C)}{\sin(A + C)} \\ &= \text{RHS}\end{aligned}$$

Hence proved.

11. $b \sin B - c \sin C = a \sin (B - C)$

Solution:

By using the sine rule we know,

$$\begin{aligned}\frac{a}{\sin A} &= \frac{b}{\sin B} = \frac{c}{\sin C} = k \\ \frac{c}{\sin C} &= k\end{aligned}$$

So, $c = k \sin C$

Similarly, $a = k \sin A$

And $b = k \sin B$

We know,

Now let us consider LHS:

$$b \sin B - c \sin C$$

Substituting the values of b and c in the above equation, we get

$$k \sin B \sin B - k \sin C \sin C = k (\sin^2 B - \sin^2 C) \dots\dots\dots(i)$$

We know,

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$$\sin^2 B - \sin^2 C = \sin (B + C) \sin (B - C),$$

Substituting the above values in equation (i), we get

$$k (\sin^2 B - \sin^2 C) = k (\sin (B + C) \sin (B - C)) \text{ [since, } \pi = A + B + C \Rightarrow B + C = \pi - A]$$

The above equation becomes,

$$= k (\sin (\pi - A) \sin (B - C)) \text{ [since, } \sin (\pi - \theta) = \sin \theta]$$

$$= k (\sin (A) \sin (B - C))$$

From sine rule, $a = k \sin A$, so the above equation becomes,

$$= a \sin (B - C)$$

$$= \text{RHS}$$

Hence proved.

$$\mathbf{12. a^2 \sin (B - C) = (b^2 - c^2) \sin A}$$

Solution:

By using the sine rule we know,

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = k$$

$$\frac{c}{\sin C} = k$$

$$\text{So, } c = k \sin C$$

$$\text{Similarly, } a = k \sin A$$

$$\text{And } b = k \sin B$$

We know,

Now let us consider RHS:

$$(b^2 - c^2) \sin A \dots$$

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Substituting the values of b and c in the above equation, we get

$$(b^2 - c^2) \sin A = [(k \sin B)^2 - (k \sin C)^2] \sin A$$

$$= k^2 (\sin^2 B - \sin^2 C) \sin A \dots\dots\dots (i)$$

We know,

$$\sin^2 B - \sin^2 C = \sin (B + C) \sin (B - C),$$

Substituting the above values in equation (i), we get

$$= k^2 (\sin (B + C) \sin (B - C)) \sin A \text{ [since, } \pi = A + B + C \Rightarrow B + C = \pi - A]$$

$$= k^2 (\sin (\pi - A) \sin (B - C)) \sin A$$

$$= k^2 (\sin (A) \sin (B - C)) \sin A \text{ [since, } \sin (\pi - \theta) = \sin \theta]$$

Rearranging the above equation we get

$$= (k \sin (A)) (\sin (B - C)) (k \sin A)$$

From sine rule, $a = k \sin A$, so the above equation becomes,

$$= a^2 \sin (B - C)$$

$$= \text{RHS}$$

Hence proved.

$$13. \frac{\sqrt{\sin A} - \sqrt{\sin B}}{\sqrt{\sin A} + \sqrt{\sin B}} = \frac{a + b - 2\sqrt{ab}}{a - b}$$

Solution:

By using the sine rule we know,

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = k$$

$$\sin A = \frac{a}{k}, \sin B = \frac{b}{k}, \sin C = \frac{c}{k}$$

Let us consider LHS,

$$\frac{\sqrt{\sin A} - \sqrt{\sin B}}{\sqrt{\sin A} + \sqrt{\sin B}}$$

Let us multiply and divide the above expression by $\frac{\sqrt{\sin A} - \sqrt{\sin B}}{\sqrt{\sin A} - \sqrt{\sin B}}$ we get,

$$\begin{aligned} \frac{\sqrt{\sin A} - \sqrt{\sin B}}{\sqrt{\sin A} + \sqrt{\sin B}} \times \frac{\sqrt{\sin A} - \sqrt{\sin B}}{\sqrt{\sin A} - \sqrt{\sin B}} &= \frac{(\sqrt{\sin A} - \sqrt{\sin B})^2}{(\sqrt{\sin A})^2 - (\sqrt{\sin B})^2} \\ &= \frac{(\sqrt{\sin A})^2 + (\sqrt{\sin B})^2 - (2\sqrt{\sin A} \times \sqrt{\sin B})}{\sin A - \sin B} \\ &= \frac{\sin A + \sin B - (2\sqrt{\sin A} \times \sin B)}{\sin A - \sin B} \end{aligned}$$

Substituting the values of a and b from sine rule in the above equation, we get

$$\begin{aligned} &= \frac{\frac{a}{k} + \frac{b}{k} - \left(2\sqrt{\frac{a}{k} \times \frac{b}{k}}\right)}{\frac{a}{k} - \frac{b}{k}} \\ &= \frac{\frac{1}{k}(a + b - 2\sqrt{ab})}{\frac{1}{k}(a - b)} \\ &= \frac{a + b - 2\sqrt{ab}}{a - b} \end{aligned}$$

= RHS

Hence proved.

14. $a(\sin B - \sin C) + b(\sin C - \sin A) + c(\sin A - \sin B) = 0$

Solution:

By using the sine rule we know,

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$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = k$$

$$a = k \sin A, b = k \sin B, c = k \sin C$$

Let us consider LHS:

$$a (\sin B - \sin C) + b (\sin C - \sin A) + c (\sin A - \sin B)$$

Substituting the values of a, b, c from sine rule in above equation, we get

$$a (\sin B - \sin C) + b (\sin C - \sin A) + c (\sin A - \sin B) = k \sin A (\sin B - \sin C) + k \sin B (\sin C - \sin A) + k \sin C (\sin A - \sin B)$$

$$= k \sin A \sin B - k \sin A \sin C + k \sin B \sin C - k \sin B \sin A + k \sin C \sin A - k \sin C \sin B$$

Upon simplification, we get

$$= 0$$

$$= \text{RHS}$$

Hence proved.

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$$15. \frac{a^2 \sin(B - C)}{\sin A} + \frac{b^2 \sin(C - A)}{\sin B} + \frac{c^2 \sin(A - B)}{\sin C} = 0$$

Solution:

By using the sine rule we know,

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = k$$

$$a = k \sin A, b = k \sin B, c = k \sin C$$

Let us consider LHS:

$$\frac{a^2 \sin(B - C)}{\sin A} + \frac{b^2 \sin(C - A)}{\sin B} + \frac{c^2 \sin(A - B)}{\sin C}$$

Substituting the values of a, b and c from sine rule in the above equation, we get

$$\begin{aligned} &= \frac{(k \sin A)^2 \sin(B - C)}{\sin A} + \frac{(k \sin B)^2 \sin(C - A)}{\sin B} + \frac{(k \sin C)^2 \sin(A - B)}{\sin C} \\ &= \frac{k^2 \sin^2 A \sin(B - C)}{\sin A} + \frac{k^2 \sin^2 B \sin(C - A)}{\sin B} + \frac{k^2 \sin^2 C \sin(A - B)}{\sin C} \end{aligned}$$

Upon simplification we get,

$$= k^2 [\sin A \sin(B - C) + \sin B \sin(C - A) + \sin C \sin(A - B)]$$

We know, $\sin(A - B) = \sin A \cos B - \cos A \sin B$

$$\sin(B - C) = \sin B \cos C - \cos B \sin C$$

$$\sin(C - A) = \sin C \cos A - \cos C \sin A$$

So the above equation becomes,

$$= k^2 [\sin A (\sin B \cos C - \cos B \sin C) + \sin B (\sin C \cos A - \cos C \sin A) + \sin C (\sin A \cos B - \cos A \sin B)]$$

$$= k^2 [\sin A \sin B \cos C - \sin A \cos B \sin C + \sin B \sin C \cos A - \sin B \cos C \sin A + \sin C \sin A \cos B - \sin C \cos A \sin B]$$

Upon simplification we get,

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$$= 0$$

$$= \text{RHS}$$

Hence proved.

EXERCISE 10.2 PAGE NO: 10.25

In any $\triangle ABC$, prove the following:

1. In a $\triangle ABC$, if $a = 5$, $b = 6$ and $C = 60^\circ$, show that its area is $(15\sqrt{3})/2$ sq. units.

Solution:

Given:

In a $\triangle ABC$, $a = 5$, $b = 6$ and $C = 60^\circ$

By using the formula,

Area of $\triangle ABC = 1/2 ab \sin \theta$ where, a and b are the lengths of the sides of a triangle and θ is the angle between sides.

So,

$$\text{Area of } \triangle ABC = 1/2 ab \sin \theta$$

$$= 1/2 \times 5 \times 6 \times \sin 60^\circ$$

$$= 30/2 \times \sqrt{3}/2$$

$$= (15\sqrt{3})/2 \text{ sq. units}$$

Hence proved.

2. In a $\triangle ABC$, if $a = \sqrt{2}$, $b = \sqrt{3}$ and $c = \sqrt{5}$ show that its area is $1/2 \sqrt{6}$ sq. units.

Solution:

Given:

In a $\triangle ABC$, $a = \sqrt{2}$, $b = \sqrt{3}$ and $c = \sqrt{5}$

By using the formulas,

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We know, $\cos A = (b^2 + c^2 - a^2)/2bc$

By substituting the values we get,

$$= [(\sqrt{3})^2 + (\sqrt{5})^2 - (\sqrt{2})^2] / [2 \times \sqrt{3} \times \sqrt{5}]$$

$$= 3/\sqrt{15}$$

We know, Area of $\triangle ABC = 1/2 bc \sin A$

To find $\sin A$:

$$\sin A = \sqrt{1 - \cos^2 A} \text{ [by using trigonometric identity]}$$

$$= \sqrt{1 - (3/\sqrt{15})^2}$$

$$= \sqrt{1 - (9/15)}$$

$$= \sqrt{6/15}$$

Now,

$$\text{Area of } \triangle ABC = 1/2 bc \sin A$$

$$= 1/2 \times \sqrt{3} \times \sqrt{5} \times \sqrt{6/15}$$

$$= 1/2 \sqrt{6} \text{ sq. units}$$

Hence proved.

3. The sides of a triangle are $a = 4$, $b = 6$ and $c = 8$, show that: $8 \cos A + 16 \cos B + 4 \cos C = 17$.

Solution:

Given:

Sides of a triangle are $a = 4$, $b = 6$ and $c = 8$

By using the formulas,

$$\cos A = (b^2 + c^2 - a^2)/2bc$$

$$\cos B = (a^2 + c^2 - b^2)/2ac$$

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$$\cos C = (a^2 + b^2 - c^2)/2ab$$

So now let us substitute the values of a, b and c we get,

$$\cos A = (b^2 + c^2 - a^2)/2bc$$

$$= (6^2 + 8^2 - 4^2)/2 \times 6 \times 8$$

$$= (36 + 64 - 16)/96$$

$$= 84/96$$

$$= 7/8$$

$$\cos B = (a^2 + c^2 - b^2)/2ac$$

$$= (4^2 + 8^2 - 6^2)/2 \times 4 \times 8$$

$$= (16 + 64 - 36)/64$$

$$= 44/64$$

$$\cos C = (a^2 + b^2 - c^2)/2ab$$

$$= (4^2 + 6^2 - 8^2)/2 \times 4 \times 6$$

$$= (16 + 36 - 64)/48$$

$$= -12/48$$

$$= -1/4$$

Now considering LHS:

$$8 \cos A + 16 \cos B + 4 \cos C = 8 \times 7/8 + 16 \times 44/64 + 4 \times (-1/4)$$

$$= 7 + 11 - 1$$

$$= 17$$

Hence proved.

4. In a $\triangle ABC$, if $a = 18$, $b = 24$, $c = 30$, find $\cos A$, $\cos B$ and $\cos C$

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Solution:

Given:

Sides of a triangle are $a = 18$, $b = 24$ and $c = 30$

By using the formulas,

$$\cos A = (b^2 + c^2 - a^2)/2bc$$

$$\cos B = (a^2 + c^2 - b^2)/2ac$$

$$\cos C = (a^2 + b^2 - c^2)/2ab$$

So now let us substitute the values of a , b and c we get,

$$\cos A = (b^2 + c^2 - a^2)/2bc$$

$$= (24^2 + 30^2 - 18^2)/2 \times 24 \times 30$$

$$= 1152/1440$$

$$= 4/5$$

$$\cos B = (a^2 + c^2 - b^2)/2ac$$

$$= (18^2 + 30^2 - 24^2)/2 \times 18 \times 30$$

$$= 648/1080$$

$$= 3/5$$

$$\cos C = (a^2 + b^2 - c^2)/2ab$$

$$= (18^2 + 24^2 - 30^2)/2 \times 18 \times 24$$

$$= 0/864$$

$$= 0$$

$$\therefore \cos A = 4/5, \cos B = 3/5, \cos C = 0$$

5. For any ΔABC , show that $b(c \cos A - a \cos C) = c^2 - a^2$

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Solution:

Let us consider LHS:

$$b(c \cos A - a \cos C)$$

As LHS contain $bc \cos A$ and $ab \cos C$ which can be obtained from cosine formulae.

From cosine formula we have:

$$\cos A = (b^2 + c^2 - a^2)/2bc$$

$$bc \cos A = (b^2 + c^2 - a^2)/2 \dots (i)$$

$$\cos C = (a^2 + b^2 - c^2)/2ab$$

$$ab \cos C = (a^2 + b^2 - c^2)/2 \dots (ii)$$

Now let us subtract equation (i) and (ii) we get,

$$bc \cos A - ab \cos C = (b^2 + c^2 - a^2)/2 - (a^2 + b^2 - c^2)/2$$

$$= c^2 - a^2$$

$$\therefore b(c \cos A - a \cos C) = c^2 - a^2$$

Hence proved.

6. For any ΔABC show that $c(a \cos B - b \cos A) = a^2 - b^2$

Solution:

Let us consider LHS:

$$c(a \cos B - b \cos A)$$

As LHS contain $ca \cos B$ and $cb \cos A$ which can be obtained from cosine formulae.

From cosine formula we have:

$$\cos A = (b^2 + c^2 - a^2)/2bc$$

$$bc \cos A = (b^2 + c^2 - a^2)/2 \dots (i)$$

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$$\cos B = (a^2 + c^2 - b^2)/2ac$$

$$ac \cos B = (a^2 + c^2 - b^2)/2 \dots (ii)$$

Now let us subtract equation (ii) from (i) we get,

$$ac \cos B - bc \cos A = (a^2 + c^2 - b^2)/2 - (b^2 + c^2 - a^2)/2$$

$$= a^2 - b^2$$

$$\therefore c(a \cos B - b \cos A) = a^2 - b^2$$

Hence proved.

7. For any ΔABC show that

$$2(bc \cos A + ca \cos B + ab \cos C) = a^2 + b^2 + c^2$$

Solution:

Let us consider LHS:

$$2(bc \cos A + ca \cos B + ab \cos C)$$

As LHS contain $2ca \cos B$, $2ab \cos C$ and $2cb \cos A$, which can be obtained from cosine formulae.

From cosine formula we have:

$$\cos A = (b^2 + c^2 - a^2)/2bc$$

$$2bc \cos A = (b^2 + c^2 - a^2) \dots (i)$$

$$\cos B = (a^2 + c^2 - b^2)/2ac$$

$$2ac \cos B = (a^2 + c^2 - b^2) \dots (ii)$$

$$\cos C = (a^2 + b^2 - c^2)/2ab$$

$$2ab \cos C = (a^2 + b^2 - c^2) \dots (iii)$$

Now let us add equation (i), (ii) and (iii) we get,

$$2bc \cos A + 2ac \cos B + 2ab \cos C = (b^2 + c^2 - a^2) + (a^2 + c^2 - b^2) + (a^2 + b^2 - c^2)$$

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Upon simplification we get,

$$= c^2 + b^2 + a^2$$

$$2(bc \cos A + ac \cos B + ab \cos C) = a^2 + b^2 + c^2$$

Hence proved.

8. For any ΔABC show that

$$(c^2 - a^2 + b^2) \tan A = (a^2 - b^2 + c^2) \tan B = (b^2 - c^2 + a^2) \tan C$$

Solution:

Let us consider LHS:

$$(c^2 - a^2 + b^2), (a^2 - b^2 + c^2), (b^2 - c^2 + a^2)$$

We know sine rule in ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

As LHS contain $(c^2 - a^2 + b^2)$, $(a^2 - b^2 + c^2)$ and $(b^2 - c^2 + a^2)$, which can be obtained from cosine formulae.

From cosine formula we have:

$$\cos A = (b^2 + c^2 - a^2)/2bc$$

$$2bc \cos A = (b^2 + c^2 - a^2)$$

Let us multiply both the sides by $\tan A$ we get,

$$2bc \cos A \tan A = (b^2 + c^2 - a^2) \tan A$$

$$2bc \cos A (\sin A / \cos A) = (b^2 + c^2 - a^2) \tan A$$

$$2bc \sin A = (b^2 + c^2 - a^2) \tan A \dots (i)$$

$$\cos B = (a^2 + c^2 - b^2)/2ac$$

$$2ac \cos B = (a^2 + c^2 - b^2)$$

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Let us multiply both the sides by $\tan B$ we get,

$$2ac \cos B \tan B = (a^2 + c^2 - b^2) \tan B$$

$$2ac \cos B (\sin B / \cos B) = (a^2 + c^2 - b^2) \tan B$$

$$2ac \sin B = (a^2 + c^2 - b^2) \tan B \dots (ii)$$

$$\cos C = (a^2 + b^2 - c^2) / 2ab$$

$$2ab \cos C = (a^2 + b^2 - c^2)$$

Let us multiply both the sides by $\tan C$ we get,

$$2ab \cos C \tan C = (a^2 + b^2 - c^2) \tan C$$

$$2ab \cos C (\sin C / \cos C) = (a^2 + b^2 - c^2) \tan C$$

$$2ab \sin C = (a^2 + b^2 - c^2) \tan C \dots (iii)$$

As we are observing that sin terms are being involved so let's use sine formula.

From sine formula we have,

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} \Rightarrow \frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

Let us multiply abc to each of the expression we get,

$$\frac{abc \sin A}{a} = \frac{abc \sin B}{b} = \frac{abc \sin C}{c}$$

$$bc \sin A = ac \sin B = ab \sin C$$

$$2bc \sin A = 2ac \sin B = 2ab \sin C$$

$\therefore$ From equation (i), (ii) and (iii) we have,

$$(c^2 - a^2 + b^2) \tan A = (a^2 - b^2 + c^2) \tan B = (b^2 - c^2 + a^2) \tan C$$

Hence proved.

9. For any ΔABC show that:

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$$\frac{c - b \cos A}{b - c \cos A} = \frac{\cos B}{\cos C}$$

Solution:

Let us consider LHS:

$$\frac{c - b \cos A}{b - c \cos A}$$

We can observe that we can get terms $c - b \cos A$ and $b - c \cos A$ from projection formula

From projection formula we get,

$$c = a \cos B + b \cos A$$

$$c - b \cos A = a \cos B \dots (i)$$

And,

$$b = c \cos A + a \cos C$$

$$b - c \cos A = a \cos C \dots (ii)$$

Dividing equation (i) by (ii), we get,

$$\frac{c - b \cos A}{b - c \cos A} = \frac{a \cos B}{a \cos C} = \frac{\cos B}{\cos C}$$

= RHS

Hence proved.



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- Chapter 3–Functions
- Chapter 4–Measurement of Angles
- Chapter 5–Trigonometric Functions
- Chapter 6–Graphs of Trigonometric Functions
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About RD Sharma

RD Sharma isn't the kind of author you'd bump into at lit fests. But his bestselling books have helped many CBSE students lose their dread of maths. Sunday Times profiles the tutor turned internet star

He dreams of algorithms that would give most people nightmares. And, spends every waking hour thinking of ways to explain concepts like 'series solution of linear differential equations'. Meet Dr Ravi Dutt Sharma — mathematics teacher and author of 25 reference books — whose name evokes as much awe as the subject he teaches. And though students have used his thick tomes for the last 31 years to ace the dreaded maths exam, it's only recently that a spoof video turned the tutor into a YouTube star.

R D Sharma had a good laugh but said he shared little with his on-screen persona except for the love for maths. "I like to spend all my time thinking and writing about maths problems. I find it relaxing," he says. When he is not writing books explaining mathematical concepts for classes 6 to 12 and engineering students, Sharma is busy dispensing his duty as vice-principal and head of department of science and humanities at Delhi government's Guru Nanak Dev Institute of Technology.

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