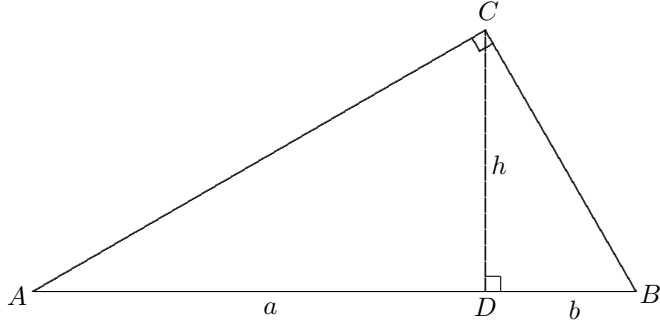


WEEK 1 EXERCISE

1. ANOTHER PROOF OF PYTHAGORAS THEOREM AND PYTHAGOREAN MEANS

Problem 1. In the following diagram, $AD = a$, $DB = b$ and $CD = h$.

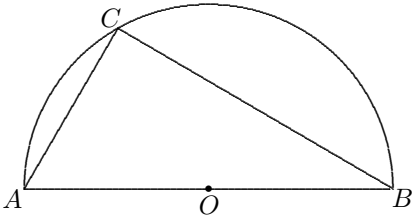


Show that $\triangle ACD \sim \triangle CBD$ and $h = \sqrt{ab}$

Remark. \sqrt{ab} is called the *geometric mean (GM)* of a and b .

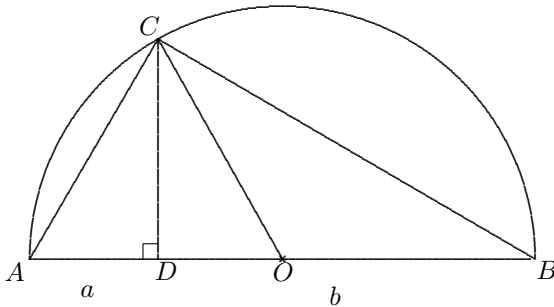
$\frac{a+b}{2}$ is called the *arithmetic mean (AM)* of a and b .

Problem 2. In the following diagram, AB is the diameter, C is a point on the semi-circle and O is the center.



Show that $\angle ACB = 90^\circ$.

Problem 3. Point D is the foot of the perpendicular from C to AB and $AD = a$ and $DB = b$.



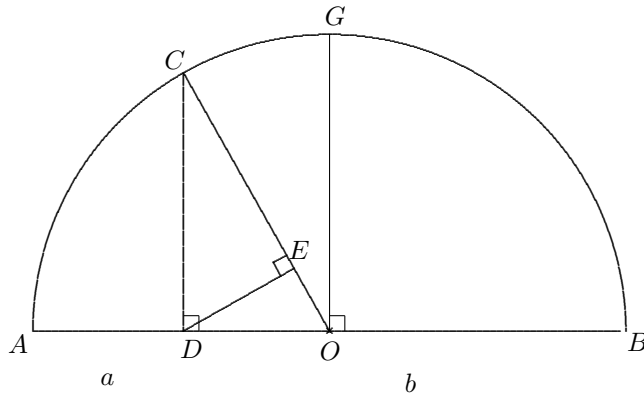
From the previous questions, we have $\angle ACB = 90^\circ$ and hence $DC = \sqrt{ab}$.

- (1) Find OC and OD in terms of a and b .
- (2) Prove the pythagoras theorem by considering $\triangle ODC$.

Remark. This shows that pythagoras theorem is true for every right triangle with sides $(\sqrt{ab}, \frac{b-a}{2}, \frac{a+b}{2})$.

Problem 4 (Construction of Pythagorean mean). In the diagram below, $AD = a$ and $DB = b$.

G is the intersection of the the perpendicular bisector of AB and the semi-circle.



In previous exercise, we show the construction of arithmetic mean and geometric mean of two line segments.

Here, we are going to construct the *harmonic mean* (HM), $\frac{2}{\frac{1}{a} + \frac{1}{b}}$, of a and b .

Finally, we construct the *quadratic mean* (QM), $\sqrt{\frac{a^2+b^2}{2}}$, of a and b .

- (1) Show that $\triangle CDO \sim \triangle CED$ and $CE = \frac{2ab}{a+b} = \frac{2}{\frac{1}{a} + \frac{1}{b}}$.
- (2) Draw the line segment DG and show that $DG = \sqrt{\frac{a^2+b^2}{2}}$.

Theorem (Mean inequality). *Let a, b be any positive real numbers, then*

$$\frac{2}{\frac{1}{a} + \frac{1}{b}} \leq \sqrt{ab} \leq \frac{a+b}{2} \leq \sqrt{\frac{a^2+b^2}{2}}$$

The equality holds if and only if $a = b$.

Proof. With refer to the diagram, the harmonic mean of a and b is the segment CE .

It is less than the hypotenuse of the triangle $\triangle CDE$, i.e. $CE \leq DC$.

DC is the geometric mean, hence we showed $HM \leq GM$.

Since DC is perpendicular to the diameter, it is less then the radius OG .

$OG = OA = OB$ hence it is the arithmetic mean.

This shows $GM \leq AM$.

Finally, a similar argument on the triangle $\triangle ODG$ shows that $AM \leq QM$

This complete the proof of the mean inequality, $HM \leq GM \leq AM \leq QM$.

If $a = b$, the above four are equal to a .

Conversely, if all of them are equal, one can show that $a = b$ algebraically. □

2. C'S SYNTAX

Rewrite the following mathematical expressions in C's expressions.

Do not simplify any one of them.

You can assume that \sqrt{x} is written as `sqrt(x)` in C.

(1) $x^3 + y^3$

(2) $(x + y)^2 (x - y)$

(3) $\sqrt{(x - y)^2}$

(4) $(\sqrt{x - y})^2$

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

(6) $\frac{x^3 + y^3}{x + y}$

(7) $x^2 - xy + y^2$

(8) $\left(\frac{x^3 + y^3}{x + y}\right)^2$

Remark. Be careful, computer is so stupid.

It cannot understand simplified notation.

For example, we may write $2xy$ usually to stand for the product of 2, x and y .

In this case, you have to write `2 * x * y`.