

1 Assignment and final tasks.

The mathematical task is to measure a large distance that cannot be measured directly such as a height as in ancient times in church architecture? You will explain a method to calculate such unaccessible distances to human size.

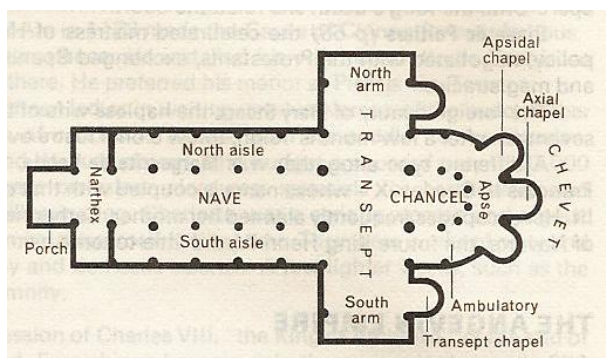
The communication task is a peer to peer students conference based on a self made poster to be given as experts in direction to visitors. All members of the team have to speak equally when presenting to the visitors.

The collaborative task is a team work in a foreign language and members are called below Alice, Bob, Charlie, David and Emmy. Feel free to share roles.

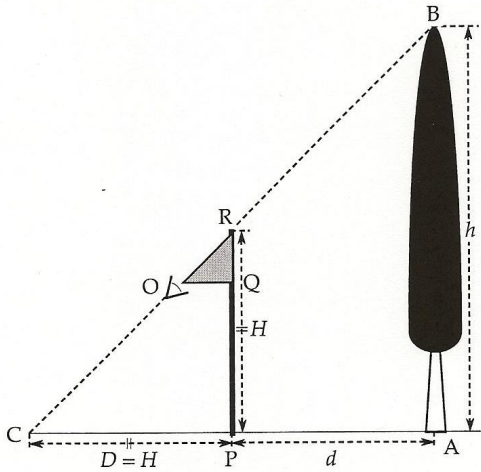
2 Measuring a human sized height

Alice chooses one of the round arches on both sides in the chancel. Consider the height from ground to the keystone of this round arch and Bob measures it with a simple measure tape. What is this height denoted by h , Charlie keeps this result in his notes for future comment.

Your task is to measure this height with the Gerbert method below and check the result. It were used back to the Middle Age and earlier to evaluate unaccessible heights such as the height of a building that cannot be measured directly with a measure tape.



3 Experiencing the method on a human sized height.



Share roles in the following instructions.

- Let $h = AB$ denote the unknown height that has to be evaluated and let $H = OP$ denote Gerbert vertical length. This stick has to be carefully held perfectly vertically. A right angled and isosceles triangle OQR is attached to the stick along one leg QR . Then the observer watches with eye positioned at point O along the hypotenuse OR such that point R apparently coincides with targeted point B . There are two ways to keep points O , R and B colinear at all times : either moving the stick to adjust distance d , or moving the triangle OQR along the stick adjusting distance H . Practice the procedure given here.
- Once points O , Q and R are colinear, measure and write the following distances :
 - vertical distance $H = RP$ between point R and ground floor. Use the ruler attached to the stick 1 metre above the ground.
 - horizontal distance $d = PA$ between stick's foot on the ground floor and the base of targeted height on the ground.
- Since triangles OQR , CPR and CAB are all isosceles and right angled respectively at point Q , P and A , their legs are pairwise of equal length. Therefore we get $h = H + d$.
- Using this rule evaluate the distance between keystone and ground and check your answer with the real measurement. Do you think that this calculating method for distances is satisfying?

4 This Gerbert stick to evaluate an unaccessible height

- Choose a much larger round arch between the nave and aisle.



2. Consider the vertical projection onto the ground of the keystone and set a rubber to mark this point. The targeted height is the distance between the keystone and the ground.
3. Apply the method given above to evaluate this distance.
4. Give an approximate value for this unaccessible height. Does this result look correct to your eyes? Comment.
5. Compare your findings with a group using a mirror as a device to measure the same heights as you just did. Do you find the same results?

5 Good to know

This instrument bears the name of Gerbert d'Aurillac, life time from about 938 to 1003. this scientist became a monk then arbishof of Reims where he taught logic and became finally pope from 999 to 1003, under the name of Sylvestre the 2nd. As a founder of a move for promoting sciences, he wrote a treaty in astronomy.

6 Bibliography

Adapted from "Finale du Rallye mathématique, vendredi 30 avril 2004, *mesure par visée de grands inaccessibles*, Jacqueline Leparmentier, Didier Trotoux, Jean-Pierre Le Goff, Cercle d'histoire des sciences de l'IREM de Basse-Normandie.

7 Provided material

a Gerbert stick

**Art, Architecture and Mathematics in the Ladies Abbey Romanesque Church, Caen:
the Gerbert stick as a measuring device. Written by O. Jenvrin and JP. Le Goff**

a double decameter measure tape, used in sport classes

a level

a plumbline

answer sheet with grid for measurements

a combined protractor square set ruler (a "Math en Main" present to each participant)

blank sheets for further drawings to be glued onto the poster

separate photos of places in the church and the church plan given in this assignment

photos of the historical diagrams

**Answer sheet to fill in the measurements,
for calculations and personal notes**

Name
Team

human sized round arch in the chancel : direct measurement gives

measurements	human sized round arch	round arch in the nave
$H = RP$		
$d = PA$		
$h = H + d$		