Disaster Prevention Education Handout using Mathematics for Junior High School Students

Country _____ Age _____ Name _____

1. **Root**

When $x^n = a$, x is defined the nth root of a.

【example】 Second root (square root) of 4 is 2.
Third root (cube root) of 27 is 3.
Fourth root of 16 is 2.

· When n is an even number,

$a > 0 \Rightarrow$ There are two nth roots, and they are expressed $\sqrt[n]{a}$, $-\sqrt[n]{a}$.

$a < 0 \Rightarrow$ There is no nth root of a.

· When n is an odd number,

Regardless the sign of a, there's one nth root of a, expressed $\sqrt[n]{a}$.

【example】 $\sqrt{4}$ is the second root of 4, so $\sqrt{4} = 2$.

([Attention] When you think about the second root of a, it is expressed $\sqrt{a}$, omit the subscript of root, 2, not $\sqrt[2]{a}$.)

$\sqrt[3]{8}$ is the third root of 8, so $\sqrt[3]{8} = 2$.

$-\sqrt{4} = -2$, $\sqrt{-4} =$ No exist, $\sqrt[3]{-8} = -2$, $-\sqrt[3]{-8} = 2$

Question 1 Find the value.

(1) $\sqrt{9} =$ (2) $\sqrt{-9} =$ (3) $\sqrt[3]{27} =$ (4) $\sqrt[3]{-27} =$

(5) $\sqrt[4]{16} =$ (6) $\sqrt[4]{-16} =$ (7) $-\sqrt[4]{16} =$ (8) $-\sqrt[4]{-16} =$

Speed of Tsunami

The speed of tsunami V(km/h) in the depth of water h(m) is given by the following formula.

$$V = 3.6\sqrt{9.8h}$$

Question2 Find the value of tsunami speed for the following depth of water.

(1) The deepest depth in ; Lake Hamana : 16 (m)

(2) The deepest depth in ; Tokyo Bay : 70 (m)

(3) The deepest depth in ; Toyama Bay : 1,200 (m)

(4) The deepest depth in ; Suruga Bay : 2,500 (m)

Height of Tsunami (Green's Law)

In one offshore, when the hight of wave is H_1(m), the depth of water is h_1(m), the hight of wave near the coast is H(m), the depth of water is h(m), H is given by the next formula.

$$H = \sqrt[4]{\frac{h_1}{h}} \times H_1$$

At the Meteorological agency, the hight of wave near the coast is defined "$h = 1$(m)".

Question3 Find the height of wave near the coast for the following two situations.

(1) The water depth and wave height are 16(m) and 1(m).

(2) The water depth and wave height are 100(m) and 2(m).

2. **Logarithm**

When $a > 0, a \neq 1$, and the following equation ① was right, m is defined **Logarithm** in the base a. In adddition, m is expressed by the following equation ②.

$$a^m = N \cdots ① \qquad m = \log_a N \cdots ②$$

The relation between index and logarithm

$$a^m = N \Leftrightarrow m = \log_a N$$

eg) $2^2 = 4$, $2 = \log_2 4$. $2^3 = 8$, $3 = \log_2 8$.
$\log_2 32 = 5$, $\log_3 9 = 2$, $\log_3 27 = 3$

Question4 Find the following values.

(1) $\log_2 64 =$ (2) $\log_4 16 =$ (3) $\log_5 125 =$

(4) $\log_{10} 10 =$ (5) $\log_{10} 100 =$ (6) $\log_{10} 10^5 =$

The relation between energy from earthquake and magnitude (Richter scale)

When the energy from earthquake is $E(J)$, the magnitude is M, E is expressed by the following formula.

$$\log_{10} E = 4.8 + 1.5M \quad \text{namely,} \quad E = 10^{4.8+1.5M}$$

Question5

Find the values of earthquake energy of $M7$, $M8$ and $M9$. Then, find how many times the earthquake energy multiple when the magnitude increases by 1 and 2.

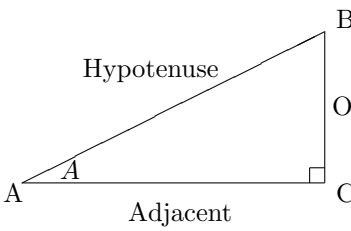
When $M7$, $E =$

When $M8$, $E =$

When $M9$, $E =$

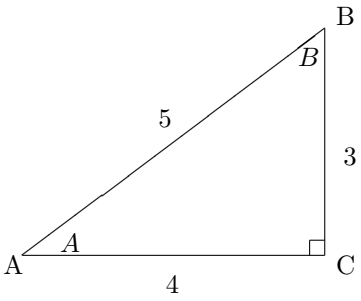
3. **Trigonometric ratio**

In three sides of right triangle ABC (Hypotenuse, Adjacent, Opposite), the two line ratios of length from an acute angle A are written as sin$A$, cos$A$, and tan$A$. These are defined like the next expressions. sin$A$, cos$A$, and tan$A$ are pronounced as sine$A$, cosine$A$, and tangent$A$. They are called **Trigonometric ratio**.



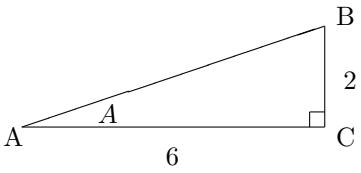
$$\sin A = \frac{\text{Opposite}}{\text{Hypotenuse}} = \frac{BC}{AB}$$
$$\cos A = \frac{\text{Adjacent}}{\text{Hypotenuse}} = \frac{AC}{AB}$$
$$\tan A = \frac{\text{Opposite}}{\text{Adjacent}} = \frac{BC}{AC}$$

【example】
Trigonometric ratio of angle A and B of following right triangle are written in next values.



$$\sin A = \frac{3}{5} \qquad \sin B = \frac{4}{5}$$
$$\cos A = \frac{4}{5} \qquad \cos B = \frac{3}{5}$$
$$\tan A = \frac{3}{4} \qquad \tan B = \frac{4}{3}$$

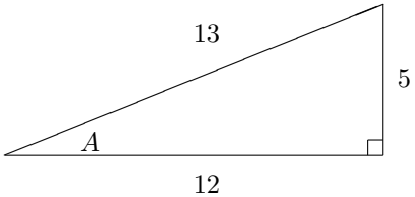
【example】
Trigoronometric ratio of angle A and B of following right triangle are written in next values using Pythagoras' theorem.



$$\sin A = \frac{1}{\sqrt{10}}$$
$$\cos A = \frac{3}{\sqrt{10}}$$
$$\tan A = \frac{1}{3}$$

Question6 Find the trigonometric ratio of angle A for following figures.

(1)

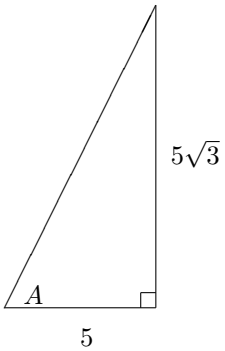


$\sin A =$

$\cos A =$

$\tan A =$

(2)

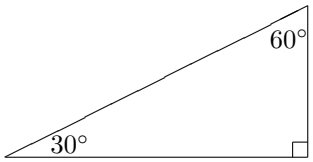


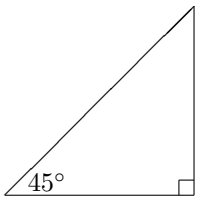
$\sin A =$

$\cos A =$

$\tan A =$

Question7 Find the trigonometric ratio of the following figures.





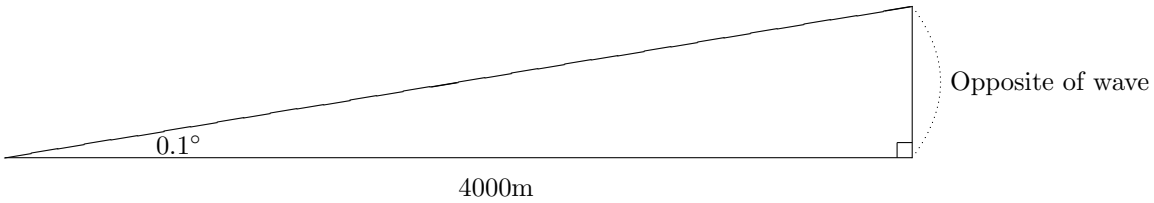
$\sin 30° =$ $\sin 45° =$ $\sin 60° =$

$\cos 30° =$ $\cos 45° =$ $\cos 60° =$

$\tan 30° =$ $\tan 45° =$ $\tan 60° =$

Question8 When you were looking out to the sea after an earthquake, the tsunami wave was appering at the horizon. The distance of the shore to the horizon is 4000(m). Find the next values.

(1) When you were looking up to the height of the tsunami , the angle of elevation was 0.1°. Find the opposite of the height of tsunami at the horizon, by refering the following figure and table.



(※ Fig1. Tsunami wave height, angle and distance from shore to the horizon.)

[Attention]
You must run away from the sea after an earthquale as soon as you can to keep your life !

angle	sin	cos	tan
0.1°	0.001745	0.999998	0.001745
0.2°	0.003491	0.999993	0.003491
0.3°	0.005236	0.999986	0.005236
0.4°	0.006981	0.999976	0.006981
0.5°	0.008727	0.999962	0.008727
0.6°	0.010471	0.999945	0.010472
0.7°	0.012217	0.999925	0.012218
0.8°	0.013962	0.999902	0.013963
0.9°	0.015707	0.999877	0.015709
1.0°	0.017452	0.999848	0.017455

(2) When the depth of water near the shore was 1(m) and the depth of water at the horizon was 1000(m), find the height of the tsunami when it arrived near the shore.