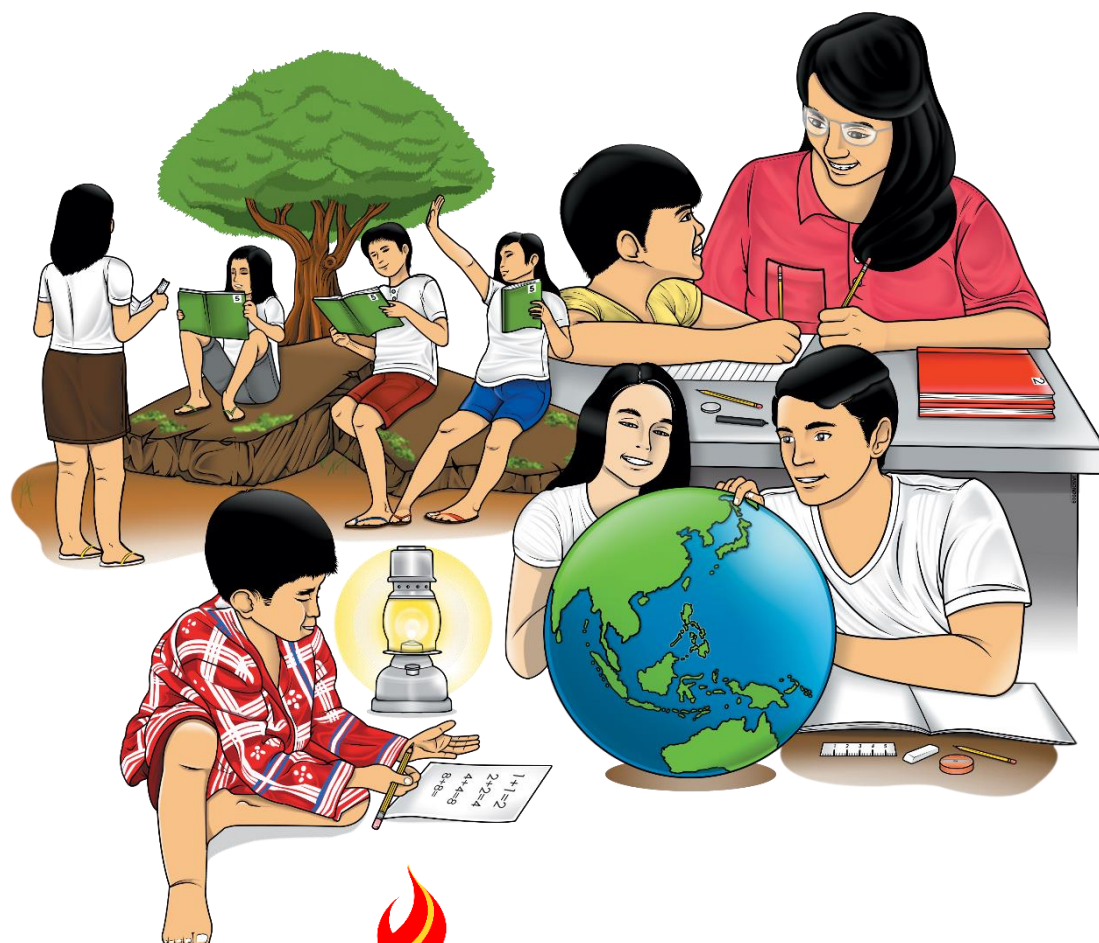


Disaster Readiness and Risk Reduction

Quarter 1 – Module 11: Earthquake Hazards and Risk Reduction Methods



Disaster Readiness and Risk Reduction
Alternative Delivery Mode
Quarter 1 – Module 11: Earthquake Hazards and Risk Reduction Methods
First Edition, 2021

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Disaster Readiness and Risk Reduction

Quarter 1 – Module 11: Earthquake Hazards and Risk Reduction Methods

Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.



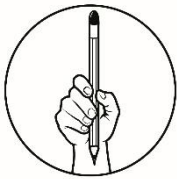
What I Need to Know

If earthquake is regarded as one of the most frightening natural disasters, that is because seconds of its occurrence can be more destructive than days of a typhoon. Besides, an earthquake comes with very little warning.

This module is intended to equip you with knowledge on various potential earthquake hazards and reduction of its risks.

After going through this module, you are expected to:

1. identify various potential earthquake hazards and ways to minimize it;
2. appreciate the value of preparedness and resilience in disastrous situations; and
3. create a comic strip about being prepared and resilient.



What I Know

Write the letter of the best answer on a separate sheet of paper.

1. What do you call the ground surface that sinks or settles due to an earthquake?
A. ground shaking
B. liquefaction
C. rupture
D. submerging
2. Which of the following is not a secondary effect of an earthquake?
A. fire
B. landslide
C. surface rupture
D. tsunami
3. Along what type of plate boundaries do earthquakes occur?
A. convergent plate boundaries
B. divergent plate boundaries
C. submergent plate
D. transform-fault boundaries
4. It refers to large ocean waves caused by violent movement in the ocean floor.
A. landslide
B. liquefaction
C. subsidence
D. tsunami
5. If you were to buy a house, where would you prefer to build it?
A. A brick building in an area underlain artificial till
B. A brick building in an area beneath granite
C. A brick structure in an area underlain by sand and silt sediments
D. All the choices above are equally good locations.

6. Many divergent plate boundaries coincide with _____.
 A. edges of the continents
 B. mid-ocean ridge
 C. transform faults
 D. volcano
7. During large earthquakes, which is responsible for the greatest number of fatalities?
 A. fires
 B. large objects (buildings) fall on people
 C. people buried alive
 D. sanitary fails
8. Earth's external heat engine is driven by what source of energy?
 A. coal
 B. natural gas
 C. petroleum
 D. Sun
9. Massive soil erosion from a hill or mountain is called _____.
 A. landslide
 B. liquefaction
 C. subsidence
 D. tsunami
10. Which can help reduce the risk of an earthquake?
 A. effective earthquake instrumentation
 B. building resistant structures
 C. hazard maps
 D. all of the above
11. The lithosphere is the portion of the Earth where rocks behave as _____.
 A. brittle solids
 B. fluid
 C. plastic solids
 D. Soft rocks
12. At transform plate boundaries, _____.
 A. Two plates slip past horizontally each other
 B. Two plates move in opposite directions away from each other.
 C. Two plates move in opposite directions toward each other.
 D. Two plates are subducted beneath each other.
13. Liquefaction is caused by _____.
 A. movement of tectonic plates
 B. motion along earth's faults
 C. shifting of bedrocks
 D. decreasing density or compactness of soil
14. Choosing the right materials and design in building your house is an example of _____.
 A. earthquake instrumentation
 B. hazard mapping
 C. structural engineering
 D. None of the above
15. Which of the following is not a secondary hazard caused by an earthquake?
 A. landslides
 B. liquefaction
 C. loss of lives
 D. tsunami

Lesson

1

Earthquake Hazards

An earthquake poses a lot of hazards which can contribute to large economic and human losses, and represents a serious impediment to socioeconomic development, creation of jobs and availability of funds for poverty reduction initiatives.

In this module, you will be introduced to the different hazards brought about by an earthquake. Earthquake hazard and risk assessment is a fundamental tool for developing risk reduction measures and constitutes the first step to support decisions and actions to reduce potential losses.

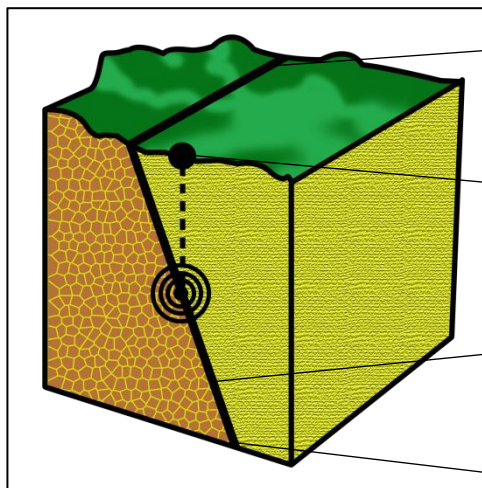


What's In

In your previous lessons about earthquake, you have learned how an earthquake starts, where it usually originates and the type of plate motion that usually causes an earthquake. Now, it is essential for you to learn what are the impending threats and hazards that go along with an occurrence of an earthquake. Ultimately, this will help you develop sense of preparedness by equipping you with necessary knowledge on the different earthquake hazards.

Before you engage with the main objectives of this module, let us have a brief throwback on important concepts about earthquake.

Can you label the picture below? Write the correct label and give the definition of the term/s inside the boxes at the right.



Now, check your answer in the Answer Key section. Did you get them right?

Let us refresh the following earthquake concepts:

- An earthquake is the vibration of Earth produced by the rapid release of energy within the lithosphere.
- Earthquakes are caused by slippage along a break in the lithosphere, called a fault.
- The energy released by an earthquake travels in all directions from the focus in the form of seismic waves.
- The movement that occurs along faults during earthquakes is a major factor in changing Earth's surface.
- Forces inside Earth slowly deform the rock that makes up Earth's crust, causing rock to bend.
- Elastic rebound is the tendency for the deformed rock along a fault to spring back after an earthquake.
- An aftershock is an earthquake that occurs sometime soon after a major earthquake.
- A seismograph is a device used to record the motion of the ground during an earthquake.

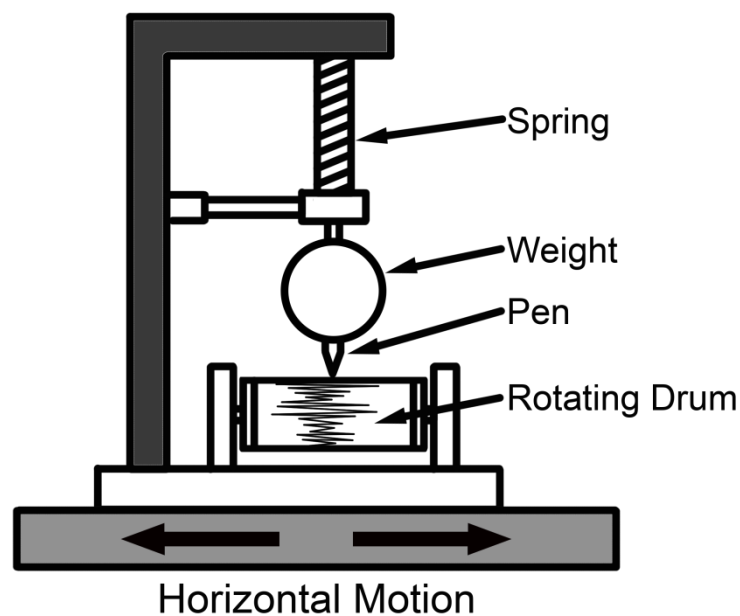


Figure 1. Seismograph



Notes to the Teacher

Aside from the review concepts in *What's In* section of this module, it is a prerequisite for the learner to have understood previous concepts on hazards and mitigation of disaster risks prior to use of this module.



What's New

Who would not know the story of Popoy and Basha? In the movie *One More Chance*, Popoy, who played the role of an architect, was able to fulfill his stubborn vision of building calamity and earthquake-proof housing projects.



Source:, Unreel Ph, "One More Chance and that one scene that broke it", February 16, 2020. 1024 x 576, Accessed July 10, 2020, <https://unreel.ph/feature/one-more-chance-confrontation-scene/>

Figure 2. Popoy playing the role of an architect wanting to build earthquake-resistant structures

Answer the following questions.

1. What do you think is the reason why Popoy thought of building earthquake-proof houses?

2. What are the possible hazards or dangers that can be caused by an earthquake?

3. Based from your previous learnings, what are the materials and structural features of an earthquake-proof house?



What is It

What are Earthquake Hazards?

Earthquake Hazards refer to earthquake agents which have the potential to cause harm to vulnerable targets which can either be humans, animals or even your environment.

The effects of an earthquake can be classified as primary or secondary.

- *Primary effects* are permanent features an earthquake can bring out. Examples include fault scarps, surface ruptures, and offsets of natural or human-constructed objects.
- *Secondary effects* happen when ground movement results to other types of destruction. Examples include landslides, tsunami, liquefaction and fire.

Below are the four earthquake hazards which are considered as secondary effects of an earthquake:

1. Landslides

Seismic vibration is a common triggering mechanism for landslides. Landslides can have particularly devastating effects like floods, blocking of rivers, death, and damage to land and natural resources. Landslides can be prevented by reinforcing slope material, modifying the pathway for surface and underwater and by putting piles and retaining walls.



2. Tsunami

A tsunami is a huge sea wave triggered by a violent displacement of the ocean floor. Underwater earthquakes, volcanic eruptions or landslides can cause tsunami. As it approaches a shallow coastline, its speed decreased, but the height of the tsunami increases drastically, bringing so much damage to nearby communities. Tsunamis can also overwhelm sewage systems, destroy structures and kill people.



3. Liquefaction

Earthquake motion can turn loosely packed, water-saturated soil to liquid—"liquefaction." Liquefied soil becomes less compact and ultimately lose the ability to support roads, buried pipes, and, of course, houses. It is caused by vibration or saturation with water which causes the soil to decrease in density. This poses danger for it leads to unstable structures of buildings due to ground subsidence.



4. Fires

Earthquakes cause fires. Even moderate ground shaking can break gas and electrical lines, sever fuel lines, and overturn stoves. To further complicate things, water pipes rupture, so it would be impossible to extinguish the fire.



Most commonly used methods of reducing earthquake risks are as follows:

1. Effective recording and interpretation of ground motion

This can be done by effective instrumentation in order to determine the location, strength and frequency of earthquakes. This assists in providing alerts and warnings especially to high-risk or vulnerable areas for preparation and emergency response.

2. Constructing seismic hazard maps

A seismic hazard map shows the potential hazards in a given area. In many regions in our country, seismic expectancy maps or hazard maps are now available for planning purposes. It serves as basis for disaster management information like locations for evacuation and evacuation routes. The anticipated intensity of ground shaking is represented by a number called the peak acceleration or the peak velocity.

3. Developing resistant structures

Resistant structures are able to withstand collapse by redistributing forces caused by seismic waves through shear walls. Developing engineered structural designs that are able to resist the forces generated by seismic waves can be achieved either by following building codes based on hazard maps or by appropriate methods of analysis.



Source: Steel for earthquake-proof houses, *Steel-Frames*, 1600 x 680, Published Nov 6, 2017 by Posco Newsroom, Accessed June 2, 2020, <https://dh4drhh3phab.cloudfront.net/en/wp-content/uploads/2017/11/Steel-Frames.jpg>

The Philippines is prone to natural calamities. For this reason, pushing for programs that build calamity-proof housing projects must be given importance. Steel, capable of withstanding enormous force without getting damaged, is usually used as frame in making such houses for it provides great deal of security. Other essential characteristics of steel are easy to maintain and can withstand the test of time and has high strength to weight ratio. Moreover, it is proven to be eco-friendly.

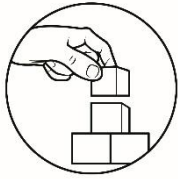
Table 1. Program options that can be taken by government and private institutions to reduce the risks of earthquake hazards

Option	Benefit/ cost range	Benefit
Earthquake scenarios	1-10	Facilitates planning for the expected and the unexpected
Building codes	1-1,000	Prevents collapse of buildings; protects life, reduces injuries
Standards and guidelines	1-1,000	Protects community infrastructure
Siting criteria for land use	1-10	Avoids surface fault rupture, soil failure, and soil-structure resonance
Relocation and rerouting	1-10	Reduces likelihood for damage to important facilities
Demolition	1-1,000	Eliminates collapse hazards and potential for loss of life
Retrofit, strengthening upgrading, and repair	1-100	Prevents collapse, eliminates vulnerabilities, and reduces damage
Performance-based design	1-100	Prevents loss of function and use
Base isolation	1-100	Ensures continued functioning of essential and critical structures
Soil remediation	1-100	Prevents liquefaction, landslides, and lateral spreading
Protective works	1-10	Prevents release of hazardous materials
Change in use	1-10	Reduces likelihood of loss of function
Change in building density	1-10	Lowers the risk to people
Insurance	1-1,000,000	Spreads the risk and enhances recovery; hope for fostering mitigation in the future
Public-private partnerships	1-10	Spreads the responsibility
Training	1-10	Expands the capability of professionals
Non-structural mitigation	1-100,000	Protects equipment and contents; ensures use

Source: Hays et al., 1998.

Source: adpc. (1001).
Earthquake Vulnerability
Reduction for Cities
(EVR-2). Notes

The options and benefits of vulnerability reduction mentioned above are based on experiences in developed countries. A refinement of approaches is necessary for selecting and implementing these options in developing countries.



What's More

Activity 1.1: Hurdling Language Barriers to Understand Science

Learning the Skill: *Defining terms using context clues*

Give the meaning of the underlined words by examining how it is used in the sentence.

1. When the soil is water-saturated, it tends to behave like a liquid. Such behavior leads to secondary earthquake effect which is called liquefaction.

2. During earthquakes, LPG tanks and stoves may overturn and electrical lines may sever, and consequently may lead to fire.

3. Seismic activities must be monitored because earthquakes originate below the earth's crust.

4. Ground subsidence happens because of the soft and liquid-like behavior of some soil.

5. A tsunami is caused by earthquake in oceanic floors. This leads to huge flooding in communities near the seashore.

Activity 1.2. What A Breakthrough!

Impact-proof desk developed for pre-school students

Published April 28, 2019, 4:02 PM

A group of researchers from the Philippine Normal University (PNU), De La Salle University, and Technological University of the Philippines developed a high impact-proof automated study desk for preschool children following recent consecutive earthquakes in Luzon and Visayas.



Life-Saving Automated Mesa to Endure Seismic Activity or the LAMESA (PHOTO COURTESY OF DOST / MANILA BULLETIN)

Called “LAMESA” for Life-Saving Automated Mesa to Endure Seismic Activity, the desk serves as a “a survival tool and a teaching aid to initiate ‘active’ disaster preparation,” according to PNU’s Dr. Marie Paz Morales, research team leader. This was done to help educational institutions become more prepared for quake-related disasters such as “The Big One”.

“The Big One”, a cataclysmic event that the Department of Science and Technology-Philippine Institute of Volcanology and Seismology (DOST-PHIVOLCS) has been forewarning for years, is expected to reach up to magnitude 8.5. Such massive force can substantially destroy populated areas in Metro Manila, including residential areas, businesses, and schools.

“La mesa” or “mesa” means “table” in Filipino.

The desk—measuring 1.22 m in length, 0.69 m in width and 3.327 cm in tabletop thickness—uses lightweight but highly strong and elastic materials to comply with kindergarten standards. Its height of 0.57 m ensures that up to four kindergarteners, with an average height of .91 m (or three feet), will be able to hide under the table.

The steel table top is coated with epoxy paint to make it durable and slick, while the steel legs come with rubber footings to minimize sliding during tremors. Its center legs, meanwhile, support a storage bin with sliding door for lighting devices plus ample food and water supplies for up to nine kindergarteners.

Moreover, LAMESA is equipped with an accelerometer, a device that senses motion, which feeds seismic measurements to a Wi-Fi-enabled microcontroller. This microcontroller then simultaneously triggers the actuator which causes the table top to fold 16 degrees upward.

LAMESA likewise has a built-in alarm system that activates when vibration levels are above-normal. Further, it has a 13-bit liquid crystal display which shows the intensity level and instructs people to evacuate when needed.

LAMESA combines technology with capacity building in terms of knowledge and infrastructure to best address such probable disaster, particularly in educational institutions.

According to the research team, they developed not only a resilient study desk for kindergartens but also a warning system when earthquakes occur, a safety infrastructure for students to use, and a learning tool to passive disaster preparation of kindergarten.

Source: Dhel Nazario, *Impact-proof desk developed for pre-school students*, Manilla Bulletin, April 28, 2019.

Guide Questions

1. What does LAMESA stand for?
2. What type of materials were used in making this impact-proof desk?
3. What are the features of the desk?
4. At an expected magnitude of 8.5, how will you describe the strength and damage does the Big One can bring?
5. How important is this invention for young children in school?
6. Why do you think these scientists came up with these inventions?
7. How important is it to be prepared and be resilient?

Activity 1.3. Info-comics

Create a 12-box comic strip which encourages people to appreciate the value of knowing earthquake hazards and risk reduction. The rubric below will serve as your guide and your teacher's basis for rating your output.

Table 2. Rubric for comic strip making

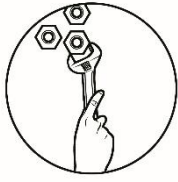
	4	3	2	1
Action	Actions make sense from one panel to another	Most actions make sense from one panel to another	Some actions make sense from one panel to another	Actions never make sense from one panel to another
Landscape and props	Relate to the action and characters in all panels	Relate to the action and characters in most panels	Relate to the action and characters in some panels	Never relate to the action and characters in all panels
Textboxes and bubbles	Well-written, edited for punctuations, grammar and usage in all panels	Well-written, edited for punctuations, grammar and usage in most panels	Well-written, edited for punctuations, grammar and usage in some panels	Not well-written, not edited for punctuations, grammar and usage in all panels
Excitement and interest	Very interesting	interesting	Somewhat interesting	Not interesting at all



What I Have Learned

Fill in the blanks with word/s that will complete the concepts you have learned in this module.

1. Earthquake refers to the sudden _____ of the ground.
2. Earthquake Hazards can cause either _____ or _____ effects.
3. Primary effects are permanent features produced by the earthquake such as _____, _____, and _____.
4. _____ effects result when ground movement causes other types of damage landslides, tsunami, liquefaction and fire.
5. There are ways to reduce the risks of an earthquake. These are _____, _____, and _____.



What I Can Do

Filipinos have been through a lot of disasters- typhoon Yolanda, fire, July 1990-earthquakes, landslides, COVID-19 pandemic. Name it and the Filipinos had been through it! Read the poem below, and then answer the questions that follow.

We Filipinos Are Disaster-Resilient, Aren't We?

By Rodgem A. Barairo

*To combat a disaster, is an impossibility
Never ever say,
We can prepare
We can think of ways
Because truth is
We're hopeless, down on bended knees*

*Never believe
The government and Filipinos are capable
Because reality is
We can't work hand in hand*

*Never believe
Our nation can be great again
Because truth is
Filipinos are not resilient*

*Forget the thought
That we can't make it
Never ever say
There's hope after a disaster!*

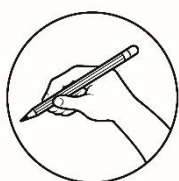
This time, read the poem in reverse, that is, from bottom to top.

Questions

1. Do you think you are a resilient person? Why do you say so?

2. Which manner of reading the poem gives a more realistic characterization of our nation's ability to respond to disasters, from-top-to-bottom, or reverse manner? Justify your answer.

3. As a senior high school student, how can you make yourself disaster-strong and resilient?



Assessment

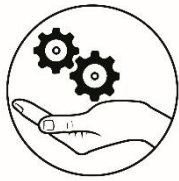
Write the letter of the best answer on a separate sheet of paper.

1. Which community will be least affected by an earthquake?
 - A. A community that is within 1km radius of the epicenter.
 - B. A community that experiences an earthquake with a depth of focus of 100km.
 - C. A densely populated community that has no earthquake preparedness measures in place.
 - D. A community that experiences an earthquake with a magnitude of 7.5.
2. Which of the following is caused by a landslide or explosion under the oceans?
 - A. fire
 - B. ground rupture
 - C. liquefaction
 - D. tsunami

3. At convergent plate boundaries, _____
- A. Two plates slip past horizontally each other
 - B. Two plates move in opposite directions away from each other
 - C. Two plates move in opposite directions toward each other
 - D. Two plates are moving vertically
4. Which of the following is NOT TRUE about reduction of earthquake risks?
- A. Hazard maps must be made.
 - B. Accurate data recording of earthquakes.
 - C. Strong and resilient buildings must be developed.
 - D. Careful analysis and interpretation of ground shaking is unnecessary.
5. Which secondary effect of an earthquake is described as collapse of buildings caused by earthquake vibrating water-saturated fill or unconsolidated soil?
- A. flood
 - B. landslide
 - C. liquefaction
 - D. tsunami
6. Many divergent plate boundaries coincide with _____.
- A. edges of the continents
 - B. mid-ocean ridge
 - C. transform faults
 - D. volcano
7. What might happen when ground shaking results to breakage of gas, electrical lines and fuel lines, and overturning of stoves?
- A. fire
 - B. landslide
 - C. liquefaction
 - D. subsidence
8. Which can help reduce the risk of an earthquake?
- A. using hazard maps
 - B. building resistant structures
 - C. utilizing effective earthquake instrumentation
 - D. All of the above

9. During large earthquakes, which is responsible for the greatest number of fatalities?
- A. drowning
 - B. fires
 - C. people buried alive
 - D. Large objects (buildings) fall on people
10. Which is not a cause of earthquake?
- A. movement of tectonic plates
 - B. changing of soil density
 - C. motion along Earth's faults
 - D. shifting of bedrocks
11. Accurate data gathering, recording and interpretation of data pertaining to ground shaking are all components of _____.
- A. hazard mapping
 - B. earthquake instrumentation
 - C. structural engineering
 - D. none of the above
12. Which of the following is a primary hazard caused by an earthquake?
- A. cracks on the ground/ faults
 - B. landslides
 - C. liquefaction
 - D. tsunami
13. When you are inside a building when earthquake begins, you should _____.
- A. Run outside immediately
 - B. Duck, cover and hold on
 - C. Go to an open space.
 - D. Call your friends and relatives to let them know if you are okay or not.
14. Which can be prevented by reinforcing slopes and rerouting of water passages?
- A. landslide
 - B. liquefaction
 - C. subsidence
 - D. tsunami

15. If you are at risk from earthquakes, what can you do to prepare for an earthquake?
- A. Choose a safe place in every room of your house like sturdy tables or desk.
 - B. Develop a family disaster plan.
 - C. Educate yourself on earthquake safety measures.
 - D. All of the above



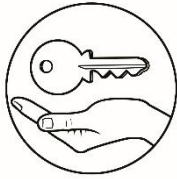
Additional Activities

Accurate information is one of the most powerful weapons in times of disasters. Your task is to make an informative, concise and attractive tri-fold brochure that contains information on earthquake risk reduction. Consider that the readers of the brochure are people from less-privileged areas.

Tri-fold Brochure Rubric

	Excellent (15-13 pts)	Good (12-10 pts)	Satisfactory (9-6 pts)	Needs Improvement (5-0 pts)
Organization of Information presented	Each section in the brochure has a clear beginning, middle, and end.	75% or more sections of the brochure have a clear beginning, middle, and end.	60% of the sections of the brochure have a clear beginning, middle, and end.	Less than half of the sections of the brochure have a clear beginning, middle, and end.
Content-Accuracy and Information validity	All facts in the brochure are accurate and match cited resources.	99-90% of the facts in the brochure are accurate.	89-90% of the facts in the brochure are accurate.	Fewer than 80% of the facts in the brochure are accurate.
Spelling & mechanics	No spelling errors and all sections of brochure are free of writing errors.	No more than 1 spelling and/or writing errors are present.	No more than 3 spelling and/or writing errors are present.	More than 3 spelling and/or writing errors are present.
Attractiveness & Organization	The brochure Has exceptionally attractive formatting and well-organized information.	The brochure has attractive formatting and well-organized information.	The brochure has well-organized information or format but not both.	The brochure's formatting and organization of material is confusing to the reader.
Graphics/ Pictures	Graphics match the topic and text in section where placed. Each section has no more than two graphics and there are at least a total of three graphics used.	Graphics go well with the text, but there are so many (more than two per section) that they distract from the text.	Graphics go well with the text, but there are too few (less than three graphics for entire brochure) and the brochure seems "text-heavy".	Graphics do not go with the accompanying text or appear to be randomly chosen.

Source: Tri-fold brochure rubric, Retrieved June 2, 2020,
http://mshartman.weebly.com/uploads/2/3/4/3/2343373/tri-fold_brochure_rubric.pdf.



Answer Key

<p>Assessment</p> <ol style="list-style-type: none"> 1. B 2. D 3. C 4. D 5. C 6. B 7. A 8. D 9. D 10. B 11. B 12. A 13. B 14. A 15. D 	<p>What's More</p> <ol style="list-style-type: none"> Activity 1.1 1. Has a lot of water/moisture 2. break 3. go down 4. underground 5. large waves 	<p>What I Know</p> <ol style="list-style-type: none"> 1. B 2. C 3. D 4. D 5. B 6. B 7. B 8. D 9. A 10. D 11. A 12. A 13. D 14. C 15. C
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<p>What's In</p> <ol style="list-style-type: none"> A. Fault- is a fracture or zone of fractures between two blocks due to ground movement. B. Epicenter- is the point on the earth's surface directly above the focus C. Focus- is also known as hypocenter; it is the origin of the earthquake. D. Fault line subsurface- a fault below the ground.
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