MSc Geophysical Hazards, UCL

Representative Exam Questions for Taught Modules
(GEOLGH01, 02, 05, 06 and 07; 03 belongs to another course, 04 is coursework only)

Candidates are requested to answer three questions in 2.5 hours

GH01. GEOLOGICAL & GEOTECHNICAL HAZARDS

1.   Describe the geophysical and geodetic methods used in the monitoring of active volcanoes [50 percent].

Explain the difference between eruption forecasting and eruption prediction. On the basis of examples you have studied, critically evaluate current approaches for forecasting and predicting volcanic eruptions. [50%]

(vi)   Outline the various magnitude scales developed to measure the size of earthquakes. [30%]

Critically evaluate the relative merits and drawbacks of the scales used to measure earthquake magnitude AND earthquake intensity. [70%]

3.   With the aid of examples, build a case for a changing climate in the post-glacial period forcing a response from the solid Earth. [70%].

Summarise the evidence for a potentially hazardous geological and geomorphological response to recent anthropogenic climate change [30%].

(i)   Using examples, describe, discuss and evaluate the roles of building design and construction, and of underlying geology, in determining the impact of some earthquakes of the last 40 years.

5.   Summarise the conditions that lead to the rapid, sub-aerial, down-slope movement of large volumes of surface material under gravity [40%]

With reference to examples, critically evaluate the range of strategies available for mitigating the effects of mass-movement hazards [60%]

6.   With the aid of illustrations, explain how a tsunami is generated by [i] a megathrust earthquake at a subduction zone; and [ii] a submarine landslide [40%].

Using evidence from the 21st century, describe and discuss the impact of tsunamis on coastal communities and infrastructure [60%].

GH02. METEOROLOGICAL HAZARDS

1. Describe the differences between a storm surge affecting the North Sea and a storm surge affecting the Baltic Sea?

2. To what extent are recent river flood events in the UK the result of climate change?

3. One of the strongest El Niño events on record peaked in late 2015. Discuss this event under the following headings, using diagrams if appropriate:
   (a) Its physical nature, cause and predictability.   [40%]
   (b) The role of the Southern Oscillation. [10%]
   (c) Its impacts on the 2015 (i) North Atlantic hurricane season, (ii) Northwest Pacific typhoon season, (iii) Indonesian rainfall, (iv) global annual temperature, and (v) global weather catastrophe losses. Provide a brief physical explanation in each case. [50%]

4. (a) Describe the basic structure of a hurricane. Include reference to dimension, cloud pattern, wind circulation and eye. [35%]
   (b) Florida was struck by seven hurricanes in 2004 and 2005. Describe how you would estimate the likelihood of this occurring in two successive years.   [15%]
   (c) Critically evaluate the following statements:
      (i) "Global tropical cyclone activity is increasing"   [15%]
      (ii) "North Atlantic hurricane activity is in decline"   [15%]
      (iii) "Hurricane track and intensity forecasts are improving steadily" [20%]

5. (a) Describe the four main meteorological types of wind that cause dust storms. Include examples of regions where each type is prevalent.   [35%]
   (b) Describe how the passage of a cold front over the Sahara Desert can influence subsequent North Atlantic tropical cyclone activity.   [30%]
   (c) Describe the nature and causes of the 1930s Dust Bowl. Would you expect the meteorological conditions that underpinned this event to happen again? [35%]

6. Write <u>brief</u> accounts of <u>THREE</u> of the following, illustrating your answers where appropriate:

   (ii) River flow measurement
   (iii)Inland tsunami
   (iii) The three basic methods used to quantify meteorological hazards.
   (iv) The life cycle of a typical European windstorm.
   (v) The main physical differences between tropical and extra-tropical cyclones. Why are windspeeds highest on the right hand side of storms in the northern hemisphere?
   (vii) The nature and potential causes of the unusually cold UK winters of 2009/10 and 2010/11.

   [33% each plus 1]

GEOLGH05. PHYSICAL VOLCANOLOGY AND VOLCANIC HAZARD

1. After several weeks of precursory unrest, an eruption has finally started at an andestic-dacitic volcano in the Philippines. The opening stages of activity have produced a lava dome. Describe the key hazards that could occur and their possible impact on local populations. Your answer should explain (a) how the hazards are connected to physical conditions during eruption, (b) the damaging range of each hazard, and (c) how quickly each hazard can become threatening.

[100%]

2. Using case histories to provide examples of good and bad practice, discuss strategies for improving the communications between monitoring scientists and decision makers during volcanic emergencies.

[100%]

3. (a) Describe how rates of volcano-tectonic event and of ground deformation can be used to make forecasts of volcanic eruptions during an emergency at stratovolcanoes in subduction zones. The answers should explain the physical processes that control the precursory signals.

[75%]

(b) A subduction-zone volcano is showing signs of renewed unrest for the first time on record. An emergency seismic network has been established that can register volcano-tectonic (VT) events. The table below gives the data obtained over a 10-day period. Using these data, estimate the time at which you consider an eruption is most likely to occur. Explain the basis for your evaluation (you may cross-reference where applicable to your answer to Part (*a*)).

[25%]

Time (days)	Daily Seismic Event Rate
1	24
2	33
3	35
4	40
5	31
6	50
7	44
10	100

4. The Campi Flegrei caldera, in southern Italy, has entered a new episode of uplift. There is concern that an eruption might be imminent. Write a report that (*a*) describes the caldera's ground deformation and eruptive activity since Roman times, and (*b*) explains the evidence that deformation has been controlled mainly by the intrusion of magma in the form of sills at depths of about 3 km below the surface.

[100%]

GEOLGH06. METEOROLOGY AND HYDROGEOLOGY

1. Describe and discuss the different ways in which mass movements in the subaerial and marine environments may be promoted. [40%]

With the aid of examples you have studied, compare and contrast the various tsunami sources associated with subaerial and submarine landslides. [60%]

2. Define and describe *East Coast* and *MCC* rainfall events that affect the UK. Include examples of flood events that have originated from these types of rainfall. [100%]

3. (a) Write brief accounts of <u>four</u> of the following procedures and techniques used in the statistical and dynamical modelling of weather and climate extremes:

        (i) Simple linear regression
        (ii) Statistical predictor selection
        (iii) Cross-validation
        (iv) Bias removal
        (v) Ensemble forecasting
        (vi) Downscaling   [80%]

(b) (i) Explain the difference between the rank correlation and the Pearson correlation. What advantage does the rank correlation offer over the Pearson correlation? [10%]

(ii) Describe the difference between a deterministic and a probabilistic forecast. What is the preferred skill measure to use in verifying the precision of deterministic seasonal hurricane forecasts. [10%]

GEOLGH07. SEISMOLOGY AND EARTHQUAKE HAZARD
(*Module in revision*)

1. You are provided with a broadband seismogram (vertical component [LHZ] of the Global Seismic Network) recorded at Matsushiro, Japan (MAJO) (Latitude: 36.54N; Longitude: 138.21E) from an earthquake (M=7.6, depth 10 km) that occurred, roughly due west in Kashmir, Pakistan, 34.49N 73.63E, at 03:52:37 (GMT) on 8th October 2005 (Fig. 1.1). You are also provided with a Jeffreys-Bullen travel-time diagram (Fig. 1.2).

(a) Identify the P wave, the S wave and the surface wave trains wherever they occur on the seismogram. Annotate the plot, making clear your reasons for your identifications. (Hand in the figure along with your answer book.)

(b) Describe how particle motions on the seismogram relates to, 1) movement of the earthquake fault and, 2) the general direction from which the signal came.

(c) Use the Jeffreys-Bullen travel-time diagram to calculate the epicentral distance (in degrees) of the earthquake, making use of the time-difference between the arrival of different phases. Discuss the sources of the errors.

(d) Use the Jeffreys-Bullen diagram to identify body wave phases on the seismograms. Comment on the identifications.

[a/b/c/d = 40/20/20/20%]

2. The 2008 eastern Sichuan earthquake with epicentre located in Wenchuan County, had the following fault plane solutions according to the USGS fast moment tensor solution, with moment magnitude, *Mw*, strike, ϕ, and dip, δ, for each nodal plane: Date Region *MW $\phi1$ $\delta1$ $\phi2$ $\delta2$* 06/05/08 31.02N 103.37E 7.9 229° 33° 352° 68° The earthquake focal depth was 19 km You are provided with a Schmidt net (Fig. 2.1) and tracing paper. You are also provided with a seismicity map of earthquakes of the Sichuan region (Fig 2.2), a fault map (Fig. 2.3) and and image of Wenchuan in the aftermath of the earthquake (Fig. 2.4).

(a) Sketch and label the focal mechanism of this earthquake, showing the orientation of the two possible fault planes. Identify the dominant type of faulting for the event. Measure the rake angles (or slip) for each of the nodal planes using your Schmidt net. Label the pressure and tension axes (*i.e.*, the P and T axes).

(b) With the aid of the seismicity map of the epicentral region (Fig. 2.2) and fault map (Fig. 2.3), interpret the focal mechanism and the regional tectonics. Discuss, with the aid of a sketch, the recent earthquake in terms of its magnitude and type of faulting in relation to its regional tectonic setting.

(c) Discuss the factors that led to the high death toll in Wenchuan and total estimated death toll of 90,000 people (see the image of Wenchuan in Fig. 2.4).

[a/b/c = 40/30/30%]

3. With the aid of labelled diagrams and example earthquakes, discuss how inSAR may be employed to: 1) determine the mechanics of an earthquake and, 2) contribute to earthquake preparedness.

4. (a) Describe the differences between earthquake magnitude, moment and intensity.

(b) Discuss how seismic waves are attenuated and amplified in the Earth.

(c) Critically assess engineering models of strong ground motion.

[a/b/c = 25/25/50%]

5. (a) What are the fundamental assumptions of a Poisson process? Explain how Poisson statistics can be applied to earthquake hazard.

(b) Show that the discrete Gutenberg-Richter distribution, described by $\log 10\ N = a - b\ m$ where N is the number of earthquakes in a magnitude range, m is earthquake magnitude and a and b are constants, can be re-written as a continuous Poisson probability density distribution of the form, $fM(x) = \beta\ e\text{-}\beta x$. (Hint, set $\beta = b \ln 10$.) What is the meaning of β ?

(c) Discuss why, with reference to a particular region, does the Gutenberg-Richter distribution have such wide applicability in earthquake hazard assessment.

[a/b/c = 30/40/40%]