

**2024 Earth and Space Scrimmage**

**Bonus**

**August 17th, 2:30 - 3:00 PT**

### TOSS-UP

1) Earth science – *Multiple Choice* Which of the following describes the direction that oceanic Rossby waves in the Northern Hemisphere typically propagate?

- W) Northward
- X) Southward
- Y) Eastward
- Z) Westward

ANSWER: Z) Westward

### BONUS

1) Earth science – *Multiple Choice* When modeled by an infinite half-space cooling model, the temperature versus depth profile follows which of the following types of functions?

- W) Power law
- X) Logarithmic
- Y) Exponential
- Z) Sigmoidal

ANSWER: Z) Sigmoidal

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### TOSS-UP

2) Earth science – *Short Answer* What empirical law describes the relationship between strain rate and normal stress in glacial ice?

ANSWER: Glen's flow law (ACCEPT: Glen-Nye flow law)

### BONUS

2) Earth science – *Multiple Choice* A parcel of air has a specific humidity of 80 grams per kilogram. In grams per kilogram and at STP, what is the air parcel's mixing ratio?

- W) 1
- X) 2
- Y) 4
- Z) 8

ANSWER: Y) 4

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**TOSS-UP**

3) Earth science – *Short Answer* What metric measures the relative amount of deformation perpendicular to applied stress?

ANSWER: Poisson's ratio

**BONUS**

3) Earth science – *Short Answer* The Boussinesq approximation for fluid flow states that the density variation between fluids is only important in the buoyancy term. Identify all of the following three statements that are true regarding fluid flow models: 1) Natural convection is primarily buoyancy driven; 2) Ocean gyres are accurately modeled through a Boussinesq approximation; 3) Hadley cells are accurately modeled through a Boussinesq approximation.

ANSWER: 1 and 2

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**TOSS-UP**

4) Earth science – *Short Answer* Identify all of the following three statements regarding the El Niño Southern Oscillation that are true: 1) Walker circulation strengthens during El Niño; 2) The Niño 3.4 index is determined by sea surface temperature anomalies; 3) The Niño 4 index measures only Modoki flavored events.

ANSWER: 2 and 3

**BONUS**

4) Earth science – *Multiple Choice* Sferics detected in radio frequencies are typically caused by which of the following phenomena?

- W) Thunderstorms
- X) Coronal mass ejections
- Y) Earthquakes
- Z) Volcanic eruptions

ANSWER: W) Thunderstorms

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**TOSS-UP**

5) Earth science – *Short Answer* Identify all of the following three statements that are true concerning the SOFAR channel: 1) The SOFAR channel transmits low frequencies better than high frequencies; 2) The SOFAR channel is located at the bottom of the thermocline; 3) The SOFAR channel is found at all latitudes.

ANSWER: 1 and 2

**BONUS**

5) Earth science – *Short Answer* Order the following three Quaternary events from oldest to youngest: 1) Bølling–Allerød Interstadial; 2) Younger Dryas; 3) Last Glacial Maximum.

ANSWER: 3, 1, 2

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**TOSS-UP**

6) Earth science – *Short Answer* Identify all of the following three statements that are true regarding Rayleigh waves: 1) Rayleigh waves are horizontally polarized; 2) Rayleigh waves are faster than S waves; 3) Rayleigh waves are typically retrograde.

ANSWER: 3 only

**BONUS**

6) Earth science – *Short Answer* Identify all of the following three statements that are true concerning oceanic Kelvin waves: 1) Kelvin waves are dispersive; 2) Kelvin waves balance Coriolis and pressure-gradient forces; 3) Equatorial Kelvin waves always propagate eastwards.

ANSWER: 3 only

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**TOSS-UP**

7) Earth science – *Multiple Choice* Under adiabatic conditions within the planetary boundary layer, which of the following function types best describes wind speed as a function of altitude?

- W) Linear
- X) Sigmoidal
- Y) Exponential
- Z) Logarithmic

ANSWER: Z) Logarithmic

**BONUS**

7) Earth science – *Short Answer* Calculate the raypath parameter for a ray on a planet with a radius of 1000 kilometers that takes off at 30 degrees from horizontal with a celerity of 5 kilometers per second.

ANSWER: 100

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**TOSS-UP**

8) Earth science – *Short Answer* What term is given to large gravity waves that are significantly affected by the Coriolis force?

ANSWER: Poincare Waves (ACCEPT: Sverdrup waves, Rotational gravity waves [from a fluids perspective])

**BONUS**

8) Earth science – *Short Answer* Identify all of the following three statements that are true regarding a double-couple focal mechanism: 1) It produces an isotropic moment tensor; 2) Two valid fault plane solutions exist; 3) The trace of the moment tensor is zero.

ANSWER: 2 and 3

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**TOSS-UP**

9) Earth science – *Multiple Choice* Harzburgite and lherzolite are typically found in which of the following regions of an ophiolite complex?

- W) Sheeted dikes
- X) Isotropic gabbro
- Y) Cumulate peridotite
- Z) Tectonized peridotite

ANSWER: Z) Tectonized peridotite

**BONUS**

9) Earth science – *Short Answer* Identify all of the following three minerals that have spinel structure: 1) Hematite; 2) Magnetite; 3) Ilmenite.

ANSWER: 2 only

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**TOSS-UP**

10) Earth science – *Multiple Choice* The end-Carboniferous minor extinction event was primarily caused by which of the following conditions?

- W) Mass volcanism
- X) Continent fragmentation
- Y) Meteorite impact
- Z) Rapid glaciation

ANSWER: X) Continent fragmentation

**BONUS**

10) Earth science – *Multiple Choice* Researchers studying Carboniferous coal have observed increased rates of wildfires during periods of high atmospheric oxygen content. Which of the following best describes the effects of this phenomenon on atmospheric oxygen and carbon dioxide content, respectively?

- W) Positive feedback, positive feedback
- X) Positive feedback, negative feedback
- Y) Negative feedback, positive feedback
- Z) Negative feedback, negative feedback

ANSWER: Z) Negative feedback, negative feedback

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**TOSS-UP**

11) Earth science – *Multiple Choice* Back-door cold fronts are meteorological phenomena that would most likely be observed in which of the following states?

- W) Texas
- X) Oregon
- Y) Florida
- Z) Massachusetts [*the-WORST-state*]

ANSWER: Z) Massachusetts

### BONUS

11) Earth science – *Multiple Choice* Henry has a sample of fluid-poor granite. He measures the  $V_p/V_s$  [**v-p-v-s**] ratio of the granite. He then saturates the same sample of granite. Which of the following best describes the effect on the  $V_p/V_s$  ratio?

- W) Decreases
- X) Stays the same
- Y) Increases
- Z) Impossible to predict

ANSWER: Y) Increases

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### TOSS-UP

12) Earth science – *Multiple Choice* Which of the following best explains the ionization of ice crystals in clouds?

- W) Tiny ice crystals contact a cold hailstone and gain a positive charge
- X) Tiny ice crystals contact a cold hailstone and gain a negative charge
- Y) Tiny ice crystals contact a warm hailstone and gain a positive charge
- Z) Tiny ice crystals contact a warm hailstone and gain a negative charge

ANSWER: Y) Tiny ice crystals contact a warm hailstone and gain a positive charge

### BONUS

12) Earth Science – *Multiple Choice* Your friend Annie is looking at some delta clasts (👁️) within a rock and notices several visible lines within the rock tilted up and to the right. She believes that these lines are markers of flow direction, which she proposes to be to the left. Why is she wrong?

- W) Delta clasts cannot be used to determine absolute flow direction as the flow can be into or out of the plane
- X) Delta clasts are examples of imbrication and flow direction is actually to the right
- Y) Delta clasts are indicative of shear stresses as the rock is actually metamorphic in origin
- Z) Delta clasts are indicative of preferred crystal growth direction as the rock is actually igneous in origin

Answer: Y) Delta clasts are indicative of shear stresses as the rock is actually metamorphic in origin

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**TOSS-UP**

13) Space science – *Short Answer* Often known as the Faber-Jackson relation for black holes, what relationship links the stellar velocity dispersion of a galactic bulge to the mass of the supermassive black hole at the galaxy center?

ANSWER: M-sigma relation

**BONUS**

13) Space science – *Multiple Choice* Which of the following best describes how Jupiter is thought to have moved throughout its evolution according to the grand tack hypothesis?

- W) Uniformly inward
- X) Uniformly outward
- Y) Inward, then outward
- Z) Outward, then inward

ANSWER: Y) Inward, then outward

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**TOSS-UP**

14) Earth science – *Short Answer* What general term describes the phenomenon where the Atlantic Meridional Overturning Circulation may respond to external forcings differently depending on its past state, which also implies the existence of multiple stable AMOC states under the same forcing state?

ANSWER: Hysteresis

**BONUS**

14) Earth science – *Short Answer* While digging a large hole for no particular reason, David notices folding at the surface with a discontinuity in the strata underneath. What type of fault has David found?

ANSWER: Blind fault



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**TOSS-UP**

15) Space science – *Short Answer* Order the following three periods of Martian history in terms of increasing length: 1) Hesperian; 2) Noachian; 3) Amazonian.

ANSWER: 2, 1, 3

**BONUS**

15) Earth science – *Short Answer* Your acquaintance claims that one-time hematite fertilization of the ocean surface off the coast of Chile will be more than sufficient to boost bioproductivity in the area for a decade or longer, provided that sufficient iron is used. Identify all of the following four statements that are plausible issues with their plan: 1) The excess hematite will be toxic to organisms; 2) The excess hematite will sink, becoming inaccessible to photosynthesizing organisms; 3) Iron(III) is not readily soluble in water; 4) Nitrogen is a more significant limiting nutrient in the South Eastern Pacific.

ANSWER: 2 and 3