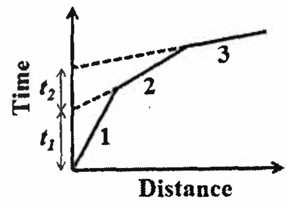
INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH KOLKATA

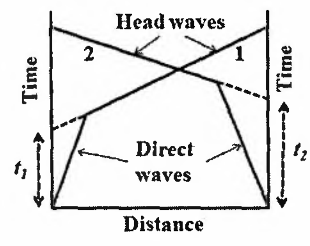
Date: *01/05/2019* Time: *2.5 Hrs.* Full Marks: **50** No. of Students: *136*
Spring Semester *2019* Department of *Earth Sciences* Sub. No.: *ES2201*
2nd Yr. BS-MS *Earth Sciences (Pre-Major)* Sub. Name: *Geophysics*
Instruction: Answer all questions

Section A

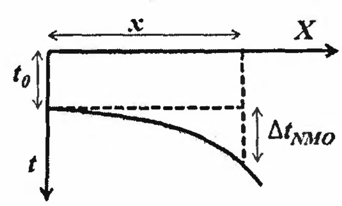
Q1. Consider a crust consists of n layers of equal thickness h and velocities v_i (i = 1, 2, ..., n). Assume that the velocities increase with depth. Derive the travel time curve for a head wave at the top of the n^{th} layer. Travel time curves for direct and head waves for three layers crust is shown in the figure. Slope of the lines 1, 2, and 3 are given by 0.5, 0.25, and, 0.125 s/km, respectively. If the thicknesses of the first and the second layer are 3 km each, calculate t_1 and t_2. (4+2 = 6)



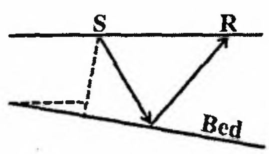
Q2. Derive the travel time for the head waves on the up-dip and down-dip path of a profile with a dipping layer. Hence, calculate dip and critical angle. For a dipping layer case, as shown in figure, 0.15 s/km is the slope of the direct wave and slope of the lines (head waves) 1 and 2 are 0.125 and 0.12 s/km, respectively. If t_1 = 2 s and t_2 = 3 s, calculate the dip, the critical angle, h_d and h_u, where h_d and h_u are the perpendicular distances of the dipping layer from the sources in the down-dip and up-dip direction, respectively. (3+1+2 = 6)



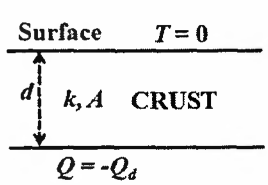
Q3. (a) A pulse reflected from a horizontal layer will arrive earliest for the zero-offset receiver, while the arrivals at longer ranges will be delayed. If the layer has thickness h, a uniform P velocity of V, and the minimum travel time, t_0, calculate normal moveout (Δt_{NMO}) from the travel time (t) versus source-receiver separation (X) graph. Hence, calculate V and h, if t_0 = 2500 s, x = 1000 m and Δt_{NMO} = 50 s. (2+1 = 3)



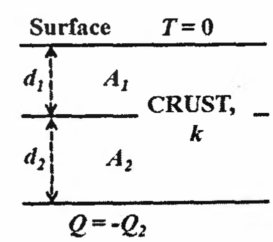
(b) A bed is dipping in the direction of seismic profile. The shot position and Geophone position are shown by S and R, respectively. If velocity (V) is uniform in the layer, θ being the dip and h is the depth of the bed from S (normal to the bed), show that dip is directly proportional to dip moveout. (3)



Q4. Derive one dimensional heat conduction equation. Calculate equilibrium crustal geotherm, if d be the depth of the Moho, Q_d be the mantle heat flow into the base of the crust, with thermal conductivity k, radioactive heat generation A and temperature (T) = 0 at depth (z) = 0. Using suitable example, show that Archean geotherm is higher than the present day geotherm. (2+1+3 = 6)



Q5. For a two-layered continental crust, the upper layer, d_1 km thick, has an internal heat generation of A_1 Wm^{-3}, and lower layer, d_2 km thick, has an internal heat generation of A_2 Wm^{-3}. Assume a surface temperature of zero, heat flow at the base of the crust is Q_2 Wm^{-2} and that the thermal conductivity is k Wm^{-1}°C^{-1}. Calculate



equilibrium geotherm for the crust. Hence, calculate the temperature (T) at 15 km depth for a two-layer crust, if d_1 = 15 km, A_1 = 4.2 μWm^{-3}, d_2 = 15 km, A_2 = 0.8 μWm^{-3}, Q_2 = -40 mWm^{-2} and k = 2.5 $Wm^{-1}{}^{\circ}C^{-1}$. (4+2 = 6)

Q6. ***Answer any three questions*** (2×3 = 6)

(a) Calculate the thickness of 100-Ma-old lithosphere using an asthenosphere temperature of 1300 °C and assuming a temperature of 1100 °C for the base of the lithosphere. (Given, thermal diffusivity = 10^{-6} m^2s^{-1})

x	0.1	0.15	0.2	0.25	0.3	0.35	0.5	1.0	1.5
erf(x)	0.112	0.168	0.223	0.276	0.329	0.379	0.520	0.842	0.966

(b) In a heat flow province, there is a linear relationship between surface heat flow (Q_0) and surface heat production (A_0) ($Q_0 = Q_r + A_0D$). If heat production is exponentially decreasing ($A_0e^{-z/D}$) with depth within a slab of thickness z^* ($D << z^*$), calculate the heat flow value at depth z^*.

(c) A seismic wave emanating from a shot point, when incident at an angle 30° at a point P on a refractor gets refracted at an angle 60°. If the wave is incident 52 m away from P, it would be critically refracted. Calculate the critical angle and the depth of the refractor.

(d) Draw the graph of the following

(i) Ray paths of PKIKP and PKP

(ii) Triplication

(iii) Horizontal slowness and vertical slowness

(iv) Receiver function

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Section B

(Select all the correct answers. Marking scheme: All correct answers +2 marks; wrong answer(s) -1; part correct answer(s) 0 marks)

Q7. Bouguer gravity anomaly for a mountain is:
(a) Free Air Anomaly – Bouguer Correction + Terrain Correction
(b) Free Air Correction – Bouguer Correction + Terrain Correction
(c) Bouguer Correction – Free Air Correction + Terrain Correction
(d) Free Air Anomaly + Bouguer Correction + Terrain Correction

Q8. The wavelength of deflection of an elastic plate due to a vertical line load V at $x=0$ is dependent on:
(a) The vertical load V (b) The elastic thickness of the plate h
(c) The shear modulus of the plate (d) The Young's modulus of the plate

Q9. Hot upwelling regions within the upper mantle is associated with:
(a) Positive gravity anomaly (b) Negative gravity anomaly
(c) Zero gravity anomaly (d) Positive Geoid anomaly

Q10. Calculate the approximate gravity anomaly across Hawaii, with a decrease in water depth of 4 km. Assume crustal rocks of density 2700 km/m^3:
(a) 600 mgals (b) 300 mgals (c) 100 mgals (d) 0 mgals

Q11. A magnetic needle will point vertically at the:
(a) Magnetic north pole (b) Geomagnetic north pole
(c) Magnetic south pole (d) Geomagnetic south pole

Q12. A mountain under 75% Airy compensation will have:
(a) Positive Free Air anomaly (b) Positive Bouguer anomaly
(c) Negative Free Air anomaly (d) Negative Bouguer anomaly

Q13. Paleomagnetic anomalies are anomaly in:
(a) Magnitude (b) Direction (c) High and Low values (d) Present field intensity

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Answer Sheet Section B: Write your answers in this table

Questions	Answers	Marks **(Do not fill)**
Q7		
Q8		
Q9		
Q10		
Q11		
Q12		
Q13		

KBose 1/5/19