THE OPEN UNIVERSITY OF SRI LANKA
BACHELOR OF TECHNOLOGY (ENGINEERING) - LEVEL 5
FINAL EXAMINATION - 2012/13

CEX5230 - SURVEYING II

Time allowed: Three hours

Date: Friday, 23rd August 2013 Time: 0930 - 1230 hours

Answer any five questions. All questions carry equal marks. Graph paper will be provided.

If you have answered more than five questions (either partly or in full), cross out the extra answers. Otherwise, only the first five answers appearing in the answer book will be evaluated.

1. The centre line of a proposed road is to be set out on a hillside to join two straights AB and BC with whole circle bearings 125° 30' and 170° 30'. Considering the existing site conditions it was necessary to construct a compound circular curve, with the first arc of radius 500 m starting from a point T_1 on AB, which is 300 m from the intersection point B. This arc deflects through an angle of 25° 00'. If the two circular arcs are joined to each other and to the two straights directly, find the radius of curvature of the second arc, and the location of the tangent point T_2 on BC.

   If it is later decided to join the circular arcs through four cubic parabolic transitions (one at each end of the two arcs), without changing the tangent points, explain the modifications to be made in the design. Give the lengths of the transition curves and the shifts of the circular arcs. The road is designed for a speed of 100 km/h, and the rate of change of radial acceleration should be limited to 0.3 m/s^3.

2. A rising grade of 4.8 % on a road is joined to a level stretch at 83.40 m above mean sea level by a parabolic vertical curve of length 180 m. The chainage of the intersection point is 2510.0 m. Find the levels along the road at 20 m intervals (and at the centre) for the purpose of setting out. Also determine the chainages of the points on the road where the gradient is 1.2, 2.4 and 3.6 % respectively.

   If a 60 mm high object lies on the road surface at the highest point on the curve, find the position from which the driver of a vehicle approaching along the rising grade will begin to see the object. You may assume the driver's eye to be 1.05 m above the road surface.

   The following formulae for sight distance, with the usual notation, may be used.

   $L = S^2A / 200 (\sqrt{h_1} + \sqrt{h_2})^2$, for $S \leq L$, and

   $L = 2S - 200 (\sqrt{h_1} + \sqrt{h_2})^2 / A$, for $S \geq L$

3. (a) The adverse working conditions experienced when conducting underground surveys as compared to surface surveys calls for special requirements in the instruments used and the procedures adopted in the former. Briefly explain how the instruments are selected or modified to satisfy these requirements.

   (b) Describe with the help of sketches, the method used to connect an underground survey of a tunnel to a surface survey when only one shaft is available.

4. Volumes of earthwork between successive cross sections at 50 m intervals on a 600 m length of a proposed road are given in the table, with a positive value indicating a cut, and a negative value a fill.

Chainage (m)	Volume (m^3)	Chainage (m)	Volume (m^3)
1600 - 1650	− 1800	1900 - 1950	+ 1500
1650 - 1700	− 2025	1950 - 2000	+ 1125
1700 - 1750	+ 125; − 1400	2000 - 2050	+ 300
1750 - 1800	+ 1575	2050 - 2100	+ 75; − 600
1800 - 1850	+ 1875	2100 - 2150	− 1950
1850 - 1900	+ 1800	2150 - 2200	− 2100

Earthwork on the road is balanced at the chainage of 1600 m. Draw the mass haul diagram for the given length of road, assuming a bulking factor of 1.10 for earth.

Clearly indicate the balancing lines for the following three scenarios.

(a) Borrowing material at chainage 1600 m only
(b) Borrowing material at chainage 2200 m only
(c) Borrowing equal volumes of material at either end

Using the following rates, find the cost of earthwork incurred in the third alternative given above.

- Excavate, cart and fill within the free haul distance of 200 m → Rs. 240 per m^3
- Excavate, cart and fill for over haul (up to a distance of 400 m) → Rs. 360 per m^3
- Borrow and fill at chainage 1600 m → Rs. 480 per m^3
- Borrow and fill at chainage 2200 m → Rs. 450 per m^3

5. Explain the meaning of a *random error*, and state the important characteristics of the distribution of such errors.

The clockwise horizontal angles shown in the table have been observed at a point O using a 1" theodolite. The relative weights of the observations are also given.

Angle	*Observed value*	*Weight*
AOB	72° 30' 25"	2
BOC	104° 20' 20"	2
COD	92° 18' 20"	2
DOA	90° 51' 00"	2
AOC	176° 50' 43"	1
BOD	196° 38' 39"	1
COA	183° 09' 18"	1

Find the most probable values of the angles at the station O using the method of correlates. Check the accuracy of the computed angles.

6. Describe in detail all the steps involved in conducting a triangulation survey, from the planning stage to the final adjustment of observed angles in the network.

Explain why it becomes necessary to construct triangulation towers at some stations, and how their heights are determined.

7. A phototheodolite having a focal length of 180 mm was used to take photographs from two stations P and Q, with the camera axis perpendicular to the line PQ at each station. The image of a control point X appeared on the two photographs as follows.

   On the print taken from P: 12.2 mm to the right of principal line and 11.4 mm above horizon line
   On the print taken from Q: 18.3 mm to the left of principal line and 5.1 mm above horizon line

   The coordinates of control point X with respect to station P were 375.0 m north and 200.0 m east.

   Find the inclination of the camera axis at Q to the horizontal, if the level of the camera axis at Q was 3.92 m higher than its level at P, where the axis was truly horizontal.