

**END OF SEMESTER EXAMINATIONS**

2ND SEMESTER 2022/2023 ACADEMIC YEAR

DATE: JULY 2023

**COURSE CODE: CVE 307**

**COURSE TITLE: HIGHWAY ENGINEERING**

**LECTURER’S NAME: PAUL AMIHERE-ACKAH**

**DURATION: 3 HOURS**

**APPENDICES**

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|  | **COURSE OUTLINE**  **(MAIN TOPICS)** | **QUESTION NO.** |
| **MajorTopic-1** | Intersection and interchanges | Q1, Q3, Q6a, Q7d, Q9b |
| **MajorTopic-2** | Highway Alignment and Route Location Survey | Q4, Q6c |
| **MajorTopic-3** | Geometric design of highways | Q5, Q8d, Q9c, Q10c |
| **MajorTopic-5** | Overview of the highway planning and development process | Q6b |
| **MajorTopic-6** | Grades and Grade Control | Q7b |
| **MajorTopic-7** | Design Speed and Design Class | Q6d, Q8c |
| **MajorTopic-8** | Stopping Sight Distance | Q7a, Q10b, Q10d |
| **MajorTopic-9** | Highway drainage | Q7c, Q10a |
| **MajorTopic-10** | Passing sight distance | Q8a, Q8b |
| **MajorTopic-11** | Earthwork computations | Q9c, Q9d |
| **MajorTopic-12** | Highway drainage system | Q10a, |
| **MajorTopic-13** | Materials and pavements | Q9a, Q2 |
| **MajorTopic-14** | Highway safety | Q9b |

**PART A (UNDERSTANDING)**

**INSTRUCTIONS: Part A contains FIVE questions. Answer ALL questions.**

**Questions**

1. Outline **FIVE (5)** factors to consider in the design of an intersection

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| **Major Topic**  Intersection and interchanges | **Blooms Designation**  **UN** | **Score**  **5** |

2. Explain why dry density is an important quantity in highway engineering.

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| **Major Topic**  Materials and Pavements | **Blooms Designation**  **UN** | **Score**  **5** |

3. Explain in your own words, the objective for an intersection design

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| **Major Topic**  Intersection and interchanges | **Blooms Designation**  **UN** | **Score**  **5** |

4. Outline **TWO (2)** instances where aerial survey is likely to be more suitable and economical in preliminary location survey.

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| **Major Topic**  Highway alignment and route location survey | **Blooms Designation**  **UN** | **Score**  **5** |

**5.** Explain meeting sight distance

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| **Major Topic**  Geometric design of highways | **Blooms Designation**  **UN** | **Score.**  **5** |

**TOTAL SCORE: 25 MARKS**

**PART B [APPLICATION AND ANALYSIS]**

**INSTRUCTIONS: Part B contains THREE questions. Attempt any TWO questions.**

**Question 6.**

1. Discuss **FOUR (4)** basic elements that you will consider in the design of at-grade intersections.

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| **Major Topic**  Intersection and interchanges | **Blooms Designation**  AP | **Score**  **6** |

1. You are the lead planning engineer for a consultancy firm responsible for a highway development and you are tasked to identify **FOUR (4)** pertinent problems of an existing road to make a recommendation for the highway development. What are the **FOUR (4)** problems you will recommend for discussion at the planning stage as a reasonable basis for the highway development?

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| **Major Topic**  Overview of the highway planning and development process | **Blooms Designation**  AN | **Score**  **7** |

1. Explain the steps involved in route location for a highway development

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| **Major Topic**  Highway Alignment and Route Location Survey | **Blooms Designation**  AP | **Score**  **7** |

1. Calculate stopping sight distance for

i) Two-lane road with two-way traffic

ii) Single-lane Road with two-way traffic

The design speed is 50 Km/h. The coefficient of friction is 0.4, and the reaction time of the driver is 3 sec. The road is level.

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| **Major Topic**  Design Speed and Design Class | **Blooms Designation**  AN | **Score**  **5** |

**TOTAL SCORE: 25 MARKS**

**Question 7**

1. A motorist traveling at 55mi/h down a grade of 5% on a highway observes a crash ahead of him, involving an overturned truck that is completely blocking the road. If the motorist was able to stop his vehicle 30ft from the overturned truck, what was his distance from the truck when he first observed the crash? Assume perception reaction time = 2.5 sec

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| **Major Topic**  Stopping Sight Distance | **Blooms Designation**  AP | **Score**  **7** |

1. Why is grade control important?

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| **Major Topic**  Grades and Grade Control | **Blooms Designation**  AN | **Score**  **6** |

1. Explain the need for a subsurface drainage system and analyze the effect of inadequate subdrainage in highway development

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| **Major Topic**  Highway drainage | **Blooms Designation**  AP | **Score**  **7** |

1. Under what **FIVE (5)** conditions are stop signs warranted at an intersection?

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| **Major Topic**  Intersection and interchanges | **Blooms Designation**  AN | **Score**  **5** |

**TOTAL SCORE: 25 MARKS**

**Question 8**

1. A vehicle initially traveling at 66 km/h skids to a stop on a 3% downgrade, where the pavement surface provides a coefficient of friction equal to 0.3. How far does the vehicle travel before coming to a stop?

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| **Major Topic**  Passing sight distance | **Blooms Designation**  AP | **Score**  **7** |

1. A vehicle initially traveling at 150 km/hr skids to a stop on a 3% downgrade, taking 200 m to do so. What is the coefficient of friction on this surface?

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| **Major Topic**  Passing sight distance | **Blooms Designation**  AN | **Score**  **7** |

1. You are shown a crash scene with a vehicle and a light pole. The vehicle was estimated to hit the light pole at 50 km/hr. The skid marks are measured to be 210, 205, 190, and 195 meters. A trial run that is conducted to help measure the coefficient of friction reveals that a car traveling at 60 km/hr can stop in 100 meters under conditions present at the time of the accident. How fast was the vehicle traveling to begin with?

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| **Major Topic**  Design Speed and Design Class | **Blooms Designation**  AP | **Score**  **6** |

1. Why are information on traffic volume necessary in road geometric design?

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| **Major Topic**  Geometric design of highway | **Blooms Designation**  AN | **Score**  **5** |

**TOTAL SCORE: 25 MARKS**

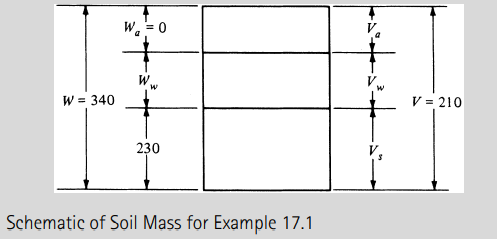
**PART C [EVALUATING AND CREATING]**

**INSTRUCTIONS: Part C contains TWO questions. Answer ONE question.**

**Question 9**

1. The wet weight of a specimen of soil is 340 g and the dried weight is 230 g. The volume of the soil before drying is 210 cc. If the specific gravity of the soil particles is 2.75, determine the void ratio, porosity, degree of saturation, and dry density. Figure 1 is a schematic of the soil mass

Figure 1: Schematic of the soil mass



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| **Major Topic**  Materials and Pavements | **Blooms Designation**  **CR** | **Score**  **7** |

1. An engineer wishing to test whether large trucks are significantly involved in crashes on rural two-lane highways than on rural multilane highways, provided data for a period of five years on randomly-selected rural two-lane and multilane highways in her district, as given in Table 1. These sections are each of the same length, with similar large truck percentages, AADT, and posted speed limits. Using the t-test, determine whether it can be concluded that large-truck-involved crashes on rural two-lane highways are significantly higher than those on rural multilane highways at a significance level of 5%. Refer to Table 2 for information on t-distribution table of critical values.

Table 1: Crashes on rural two lane and multi-lane highways

|  |  |  |  |
| --- | --- | --- | --- |
| Number of large-truck involved crashes on two-lane rural roads over five years | | Number of large-truck involved crashes on multiple lane rural roads over five years | |
| Site number | Number of crashes | Site number | Number of crashes |
| 1 | 31 | 1 | 30 |
| 2 | 35 | 2 | 33 |
| 3 | 28 | 3 | 26 |
| 4 | 29 | 4 | 30 |
| 5 | 33 | 5 | 30 |
| 6 | 26 | 6 | 27 |
| 7 | 30 | 7 | 28 |
| 8 | 30 | 8 | 32 |
| 9 | 27 | 9 | 26 |
| 10 | 33 | 10 | 28 |

Table 2: t-Distribution table of critical values

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| one-tailed α | 0.10 | 0.05 | 0.025 | 0.01 | 0.005 | 0.0005 |
| two-tailed α | 0.20 | 0.10 | 0.05 | 0.02 | 0.01 | 0.001 |
| df |  |  |  |  |  |  |
| 1 | 3.078 | 6.314 | 12.71 | 31.82 | 63.66 | 636.62 |
| 2 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 | 31.599 |
| 3 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 | 12.924 |
| 4 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 | 8.610 |
| 5 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 | 6.869 |
| 6 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 | 5.959 |
| 7 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 | 5.408 |
| 8 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 | 5.041 |
| 9 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 | 4.781 |
| 10 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 | 4.587 |
| 11 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 | 4.437 |
| 12 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 | 4.318 |
| 13 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 | 4.221 |
| 14 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 | 4.140 |
| 15 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 | 4.073 |
| 16 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 | 4.015 |
| 17 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 | 3.965 |
| 18 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 | 3.922 |
| 19 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 | 3.883 |
| 20 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 | 3.850 |
| 21 | 1.323 | 1.721 | 2.080 | 2.518 | 2.831 | 3.819 |
| 22 | 1.321 | 1.717 | 2.074 | 2.508 | 2.819 | 3.792 |
| 23 | 1.319 | 1.714 | 2.069 | 2.500 | 2.807 | 3.768 |
| 24 | 1.318 | 1.711 | 2.064 | 2.492 | 2.797 | 3.745 |
| 25 | 1.316 | 1.708 | 2.060 | 2.485 | 2.787 | 3.725 |
| 26 | 1.315 | 1.706 | 2.056 | 2.479 | 2.779 | 3.707 |
| 27 | 1.314 | 1.703 | 2.052 | 2.473 | 2.771 | 3.690 |
| 28 | 1.313 | 1.701 | 2.048 | 2.467 | 2.763 | 3.674 |
| 29 | 1.311 | 1.699 | 2.045 | 2.462 | 2.756 | 3.659 |
| 30 | 1.310 | 1.697 | 2.042 | 2.457 | 2.750 | 3.646 |
| 40 | 1.303 | 1.684 | 2.021 | 2.423 | 2.704 | 3.551 |
| 60 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 | 3.460 |
| 80 | 1.292 | 1.664 | 1.990 | 2.374 | 2.639 | 3.416 |
| 100 | 1.290 | 1.660 | 1.984 | 2.364 | 2.626 | 3.390 |
| 1000 | 1.282 | 1.646 | 1.962 | 2.330 | 2.581 | 3.300 |
| *z* | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 3.291 |

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| **Major Topic**  Intersection and interchanges | **Blooms Designation**  **EV** | **Score**  **7** |

1. Earthwork quantities for section of a roadway indicate a transition from fill to cut. The following areas are scaled from printed cross-sections. Using average end areas, what is the total required fill and cut volume for this project?

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| --- | --- | --- |
| Station | Cut area (m2) | Fill area (m2) |
| 20+00 | - | 173.21 |
| 20+10.5 | (The cut started here) | 43.56 |
| 20+21.50 | 14.32 | 9.63 |
| 20+28.45 | 64.73 | (The fill finished here) |
| 20+40 | 187.42 | - |

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| **Major Topic**  Earthwork computations | **Blooms Designation**  **CR** | **Score**  **7** |

1. Discuss shrinkage and swell.

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| **Major Topic**  Earthwork computations | **Blooms Designation**  **EV** | **Score**  **4** |

**TOTAL SCORE: 25 MARKS**

**Question 10**

1. With the aid of a diagram, explain the significance of transverse drains.

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| **Major Topic**  Highway drainage systems | **Blooms Designation**  **CR** | **Score**  **7** |

1. You see an object lying across the road and need to stop. If your vehicle was initially traveling at 100 km/h and skids to a stop on a 2.5% upgrade, taking 75 m to do so, what was the coefficient of friction on this surface?

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| **Major Topic**  Stopping sight distance | **Blooms Designation**  **EV** | **Score**  **7** |

1. A multiple regression analysis shows the following relationship for the number of trips per household.

T = 0.82 + 1.3P + 2.1A

Where T = number of trips per household per day

P= number of persons per household

A= number of autos per household

If a particular TAZ contains 250 households with an average of 4 persons and 2 autos for each household, determine the average number of trips per day in that zone

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| **Major Topic**  Geometric design of highways | **Blooms Designation**  **CR** | **Score**  **6** |

1. **D**etermine the safe stopping sight distance while traveling at speed of 60 kmph. Assuming perception and brake reaction time is 2.5 sec. and coefficient of friction varying from 0.40 at 20 kmph to 0.35 at 100 kmph.

Case:

1. level Ground

2. Upward gradient of 3%

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| **Major Topic**  Stopping sight distance | **Blooms Designation**  **EV** | **Score**  **5** |

**TOTAL SCORE: 25 MARKS**

**END OF QUESTION PAPER**