UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2023/2024

COURSE NAME	:	TRANSPORTATION ENGINEERING
COURSE CODE	:	BFT 40303
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JANUARY/FEBRUARY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

Q1 Transportation system is an important part of development of the country. However, transport engineers are often faced with the challenge of getting existing transportation facilities to operate at their most productive and efficient levels.

(a) Explain the main objective of Transportation System Management (TSM).

(3 marks)

(b) Discuss **FOUR (4)** solutions of TSM that applying efficient use of road space.

(10 marks)

(c) Elaborate the strategies to mitigate the problem of Congestion, Safety and Pollution by using Intelligent Transport System approach.

(12 marks)

Q2 The design of rail transportation tracks is critical to ensuring the safety and comfort of users.

(a) A new High-Speed Rail (HSR) railway track that will requires superelevation on a curve with a radius between 1200 to 1300 m is to be proposed to accommodate a new design speed range of 150 to 350 km/h.

(i) Check if the existing superelevation is adequate.

(8 marks)

(i) Determine the minimum length of spiral curve that is required to connect a tangent to the horizontal curve on the proposed track.

(5 marks)

(b) The distance between the Points of Vertical Intersection (PVIs) of two vertical curves, a crest curve followed by a sag curve, on an urban rail transit main line track is 1200 m. The grade of the approaching tangent of the crest curve is 3% and that of the departing tangent of the sag curve is 5%. Determine the desired, preferred minimum and absolute minimum lengths of each of these curves if the design speed of the track is 90 km/h.

(12 marks)

Q3 The infrastructures and operations of airport runways must be well-designed to maximize its safety and functionality.

(a) Decision has been made to establish an airport at an elevation of 610 meters above sea level, in a region characterized by a typical maximum temperature of 26.7°C. The airport will serve 100% fleet and 90% useful load of a family of airplanes having a maximum certificated load of 272,000 N. There exists a drop of 10 meters in the centreline elevation between the highest and lowest places of the runway.

(i) Calculate the minimum unadjusted length of the primary runway.

(2 marks)

(ii) Analyse the minimum length of the primary runway, considering wet and slick conditions during landing and the difference in centreline elevation during take-off.

(6 marks)

(iii) Provide an estimation of the minimum length necessary for the crosswind runway.

(2 marks)

(b) Currently, the utilization of an airport runway is mostly for accommodating large and heavy aircraft, as indicated by the features outlined in **Table Q3.1**. The longitudinal separation criteria can be found in **Table Q3.2**. It should be noted that the length of the final approach is 8 nautical miles.

Table Q3.1 Aircraft population characteristics

Aircraft type	**Maximum take-off weight (tons)**	**% of Total population**	**Velocity (knots)**	**Occupation time (sec)**
Large	6.25-150	80	130	50
Heavy	>150	20	140	90

Table Q3.2 Longitudinal separation requirements (in nautical miles)

Leading aircraft, *i*	**Trailing aircraft, *j***	
	Large	**Heavy**
Large	4	4
Heavy	6	5

Note: 1 nautical mile = 1.852 km

(i) Determine the minimum separation times (T_{ij}) for leading aircraft, i and trailing aircraft, j.

(8 marks)

(ii) Calculate the probabilities of two aircraft types leading and trailing each other (p_{ij}).

(4 marks)

(iii) Analyse the maximum throughput capacity for the runway.

(3 marks)

Q4 The fendering system is a crucial aspect of port operations. It needs to consider both the elements present in seawater and the ship itself.

(a) A ship proceeds towards the harbour at a constant speed. When the ship's pilot halted the ship, it was discovered that it was still traveling toward the berth. Describe the phenomenon's name and the mechanism by which it is happening within the context of water transportation engineering.

(3 marks)

(b) Elaborate the concepts behind these elements:

i. Eccentricity Effect, C_E
ii. Water Cushion Effect, C_C
iii. Softening Effect, C_S
iv. Approach Velocity, v

(8 marks)

(c) A ship's design parameters include a displacement (M_d) of 5,000 tonnes, a length (L) of 200 meters, a breadth (B) of 18 meters, and a depth (D) of 12 meters. The ship maintains a perpendicular orientation regarding the line of the berth when navigating in open waters. The following assumptions have been made:

Berthing angle (ϕ)	:	50°
Distance of point of contact from the centre of mass (r)	:	20 m
Water cushion factor (C_C)	:	0.8
Softening factor (C_S)	:	1.0
Specific gravity of sea water (ρ)	:	1.0
Safety factor	:	1.5
Berthing conditions	:	Good berthing conditions, exposed

(i) Evaluate the ship's berthing velocity (V) and calculate the hydrodynamic mass factor (C_H).

(5 marks)

(ii) Examine the berthing coefficient (C).

(3 marks)

(iii) Calculate the energy that can be absorbed by the fender (E_f).

(2 marks)

(iv) Suggest the type of rubber fender that will be able to withstand a 5,000 kN horizontal force.

(4 marks)

- END OF QUESTIONS -

APPENDIX A Design Tables and Charts

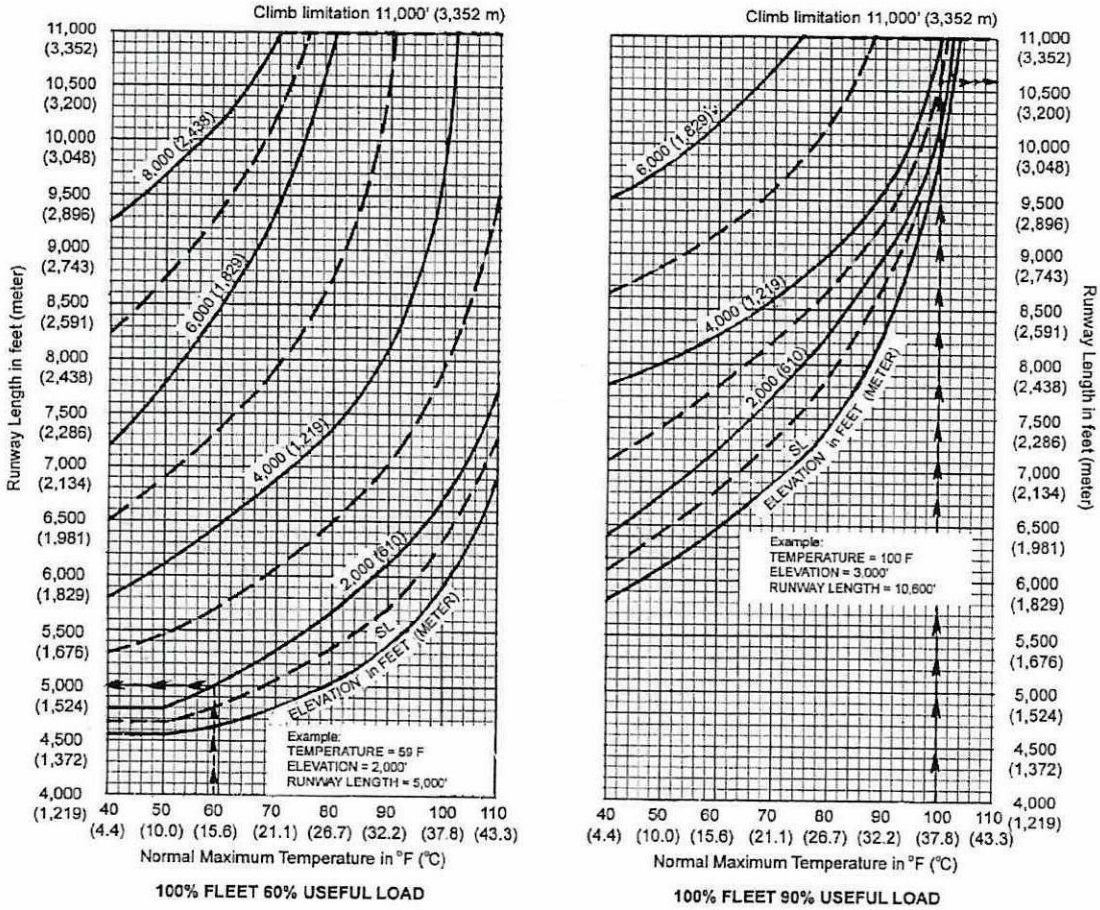

Figure APPENDIX A.1 Runway length to serve 100% of large planes of 272,000 N or less

Table APPENDIX A.1 Maximum grades for light rail main line railway tracks

Length between points of vertical intersection	**Maximum sustained grade (%)**
more than 750 m	4
up to 750 m	6
up to 150 m	7

Table APPENDIX A.2 Fender factor for different types of rubber fender

No.	**Rubber fender**	**Dimensions**	**Cross-section**	**Total impact reaction (kN)**	**Fender factor (P/E_f)**
1	Pneumatic	Diameter = 2.0 m Length = 3.5 m	Circular	400	3.33
2	Cord strips	Diameter = 1.0 m	Circular	690	5.75
3	V-type	Height = 0.5 m Length = 2.0 m	Trapezoidal	750	6.25
4	Cylindrical	Diameter = 0.61 m	Circular	1200	10
5	Solid	Height = 0.15 m	Rectangular	6000	50

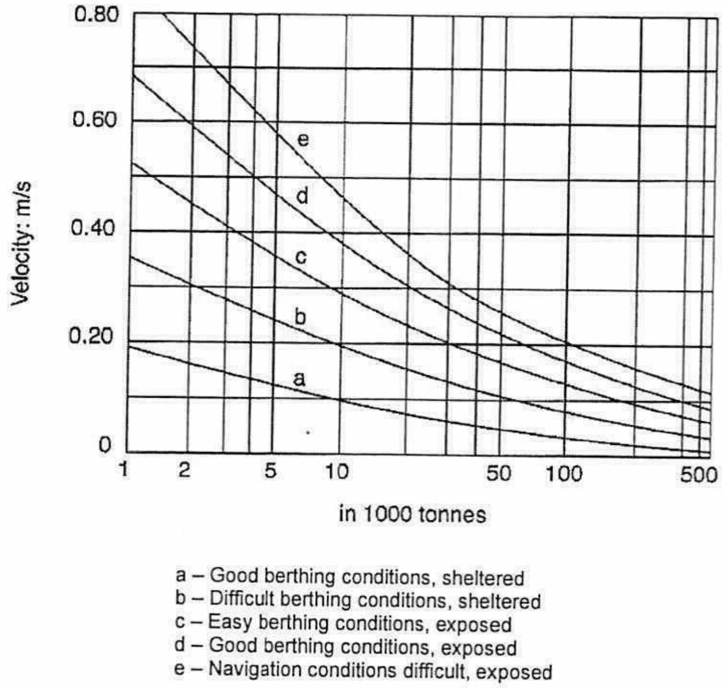

Figure APPENDIX A.2 Design berthing velocity due to ship displacement

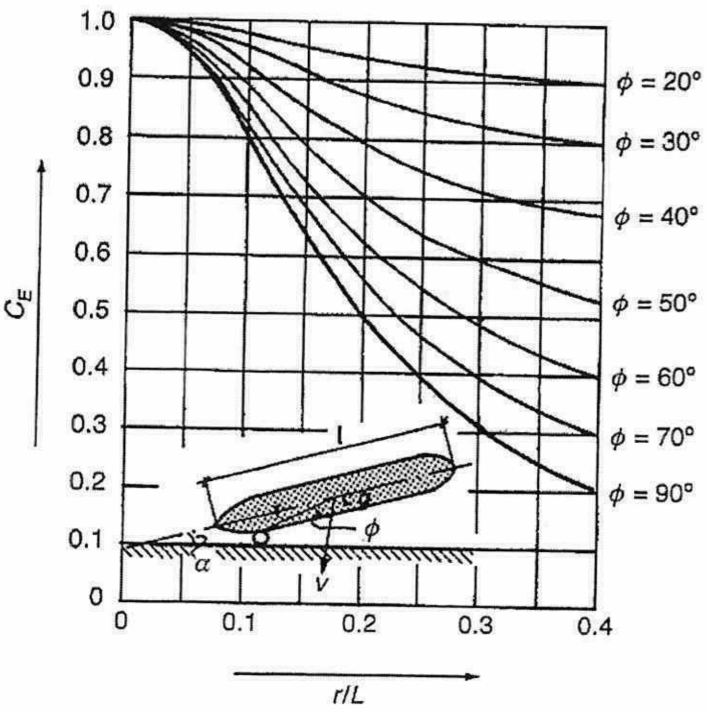

Figure APPENDIX A.3 Eccentricity factor as function of ϕ and r/L

APPENDIX B Formulas

These formulas may be useful to you. The symbols have their usual meaning.

$$LVC_{des} = 60A \qquad LVC_{min\,pref} = 30A \qquad LVC_{min\,abs(crest)} = \frac{Au^2}{212}$$

$$LVC_{min\,abs(sag)} = \frac{Au^2}{382} \qquad R = \frac{1718.89}{D_c} \qquad e_a = 0.79\left(\frac{u^2}{R}\right) - 1.68$$

$$e_q = e_a + e_u \qquad e_q = 0.00068u^2 D_c$$

$L_{min\,spiral} = 0.122 e_u u$ to satisfy unbalanced acceleration

$L_{min\,spiral} = 7.44 e_a$ to satisfy racking and torsional forces

$$E[T_{ij}] = \sum_{i=1}^{K}\sum_{j=1}^{K} p_{ij} T_{ij}$$

$$T_{ij} = max\left[\left(\frac{r + s_{ij}}{v_j} - \frac{r}{v_i}\right), o_i\right] \quad when\ v_i > v_j$$

or

$$T_{ij} = max\left[\frac{s_{ij}}{v_j}, o_i\right] \quad when\ v_i \le v_j$$

when aircraft is at runway threshold

$$E_f = C \times \left(0.5 \times M_d \times V^2\right) \qquad C_H = 1 + \left(\frac{M_h}{M_d}\right) C_{HR} \qquad M_h = \frac{1}{4}\pi \times \rho \times D^2 \times L$$

$$C = C_H \times C_E \times C_C \times C_S \qquad F_f = \frac{P}{E_f}$$