BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA
L-4/T-1 B. Sc. Engineering Examinations 2018-2019
Sub : **NAME 415** (Marine Maintenance and Repair)
Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.
USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Assume reasonable value for missing data (if any)

1. (a) It is most difficult to repair cracks in hull plating which do not reach the edge of plates, and cracks in structural parts of machinery. **(2+2+8)**

   i. What is the reason of this difficult?

   ii. How will you reduce this difficulty?

   iii. Describe with necessary sketches how these kinds of cracks can be repaired.

   (b) In ship repairing there arises the need for the straightening of bent crankshafts, rotor shafts, transmission shafts, piston rods, connecting rods, and other shaft like components. **(3+1+8)**

   i. Explain the fundamental physical process involved in straightening of shafts and shafts like components.

   ii. List the methods of straightening of shafts.

   iii. Which method will you recommend when the deformations of the shafts are large and the shafts are rigid? Describe the method.

   (c) "The repair of cast iron components which reveal damage in the form of cracks or fractures can be executed not only by welded joints, but also by special joints such as tie pieces and inserts" - Justify the statement. **(11)**

2. (a) When repairing and preparing details of ship machinery and installations for service, much attention is paid to developing and introducing measures for protecting the parts from wearing, thus ensuring a longer service life. **(2+4+8)**

   i. What are these measures?

   ii. What are the advantages and disadvantages of electrical sputtering process?

   iii. Briefly discuss the various stages oif sputtering process with necessary sketch.

   (b) "Welding cast iron is much more difficult than welding steel." -why? How this problem can be solved while repairing cast iron components? **(3+4)**

   (c) Discuss about the zinc galvanizing process mentioning the merits, demerits and applications. **(6)**

   (d) Galvanic processes are associated with the release of a large amount of vapours, gases, and dust, which are harmful to human organism, and also involve the handling of toxic materials. What are the principal measures taken in galvanizing shops to protect the health of workers? **(8)**

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3. (a) What is fouling? What are the factors affecting fouling? Give a comparative study among available antifouling paints based on their performances, cost and environmental impacts. **(20)**

   (b) Formulate mathematical expression for measuring misalignment of shaft couplings using breakage and eccentricity. **(15)**

4. (a) A passenger vessel named M.V. Moharaj was suddenly sunk the last week due to storm and overloading. So it is immediately necessary to repair the vessel (last repair works was done about 2 years ago) and the owner is interested to repair his vessel at your dry dock yard. The owner provides the following particulars of the vessel:

   Displacement : 5000 ton

   LOA : 70m

   LPP : 68m

   BM : 10.75m

   Draft maximum : 3.5m

   Height of boot-top : 0.4m

   Height of top sides: 1.5m

   Height of bulwark: 1m

   Estimate:

   i. Man-hour required for berth preparation.

   ii. Man-hour required for dock services.

   iii. Calculate: underwater area, boot-top area, top sides area, bulwarks area & total painting area of the ship hull.

   iv. Man-hour required for removal of rudder survey.

   v. Required weight of zinc anode.

   vi. Man-hour required for fender works of 200mm diameter (15m shaft run & 8m curved)

   vii. Man-hour required for repairing anchors and cables for two anchors (cable diameter 30mm)

   [Necessary data: p=k=0.8, Number of years between dry docks for zinc = 3 years. for zinc anode replacements use the manufacturer supplied information: current density $20 mA/m^2$, capacity = 781 amp hours/kg]

   (b) A cargo vessel has been hit by a small petrol boat due to poor visibility caused by thick fog. Fortunately the crews onboard were rescued in time but the damage on the hull of the vessel was severe. It is carried to Chittagong Dockyard and after a through visual impaction the damages found on the hull are:

   i. Damage of ten external shell plates each of dimension 2.5m × 2.5m × 10mm thickness with double curvature with these below waterline and the rest above.

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ii. Damage of the midship includes shell plate flat vertical of dimension 3.5m × 2m × 10mm thickness and two in number, one keel plate of dimension 2m × 2m × 12mm thickness with single curvature, and three bottom shell of dimension 2.5m × 2m × 12mm thickness with double curvature.

iii. Damage of internal bulkhead of dimension 13m × 12m × 7mm thickness positioned at 14m aft of midship.

iv. Damage of four transverse internal T members of length 12m each above double bottom and of dimension 85mm × 85mm × 7mm thickness with double curvature.

v. Damage of two longitudinal internal T members below double bottom area each of 20 m length and having dimension 85m × 85m × 7mm thickness with double curvature.

vi. Damage of bilge strake of dimension 0.5m × 3m × 7mm thickness positioned at 14m aft of midship.

Estimate how much steel will be required and the amount of repair will be needed in terms of man-hour for removal, fairing and re-fitting of the entire above mentioned hull plates and members in place.

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Suppose, you have been recently appointed as an Assistant Naval Architect at Qarth Dry Dock Limited (QDDL). As your first assignment the management wants to give you the responsibility to oversee the next dry docking.

   Before you are officially given the order, the Managing Director of QDDL wants to find out how much you understand about dry docking. So, he asks you the following questions.

   Answer these in your script.

   (a) What are the different methods of docking of ships in a dry dock or floating dock? Illustrate them. **(10)**

   (b) How is the dock and ship prepared for dry docking? **(10)**

   (c)Work in dock starts with the cleaning of hull. Briefly describe the known methods of hull cleaning. **(10)**

   (d) If any positioning inaccuracy or list, when weight of the ship is being taken up by the blocks, occur: how would you react to these situations? **(5)**

6. (a) "As a result of their use in service, parts of engines, machinery and ship installations lose wholly or partly, their original quality." - Briefly discuss the various forms of **(10)**

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Contd..... Q. No. 6(a)

damage, which generally cause these losses of original qualities.

(b) What do you understand by absolute wear of a specimen and wearing intensity? **(10)**
Describe the methods of determining the magnitude of wear, using lubricating oil and radioactive isotope.

(c) Before a defect survey, a number of preliminary operations have to be performed.. Why do you think these are done? Mention the hull side and machinery side preliminary operations. **(8)**

(d) Mention the points that should be observed in test of water tightness by floating. **(7)**

7. (a) Cracks are a form of common damage widely distributed over parts of hull and machinery. Though impact is the primary reason for the cracks as a Naval Architect you know that, there are other sources of this damage. **(15)**
Mention the other reasons behind cracks on hull and machinery? Also describe the methods of detecting surface cracks.
(b) How are dents caused and how are they measured? Describe different methods of rectifying dent. **(15)**
(c) What part of the framing in the ship faces the most unfavorable condition which results in intensive corrosion? Why do you think this is so? **(5)**

8. (a) Write a short note on Erosion of propeller. **(13)**
How do the conditions of blade surface and propeller material influence erosion?
(b) How are deformed propeller blades straightened? **(12)**
(c) In the presence of cracks and fractured blade, how is a propeller rectified? **(10)**

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Table 1. Shifting of blocks after docking vessel

DWT	Man-hours	
	Keel block	Side block
< 20000	5	3
20000-100000	10	5
100000-200000	16	8
> 200000	20	12

Table 2. Dock services

Service	Man-hours	
	<100 LOA	>100 LOA
Fire and Safety watchman per day	8/shift	8/shift
Garbage skip per day	2	4
Electrical shore power connection and disconnection	4	5
Electrical shore power per unit	Variable	Variable
Temporary connection of fire main to ship's system	5	6
Maintaining pressure to ship's fire main per day	3	3
Sea circulating water connection	3	4
Sea circulating water per day	4	4
Telephone connection on board ship	3	3
Supply of ballast water per connection	6	8
Supply of fresh water per connection	3	5
Connection and disconnection of compressed air	3	5
Gas-free testing per test/visit and issue of gas-free certificate	8	10
Electric heating lamps per connection.	4	5
Ventilation fans and portable ducting each	5	5
Wharfage:	Variable	Variable
Cranage:	Variable	Variable

Table 3. Removal of rudder for survey
(a) Repacking stock gland with owner's supplied packing. Measuring clearances, *in situ*.
(b) Disconnecting rudder from palm and landing in dock bottom for survey and full calibrations. Refitting as before on completion.

DWT	Man-hours	
	(a)	(b)
>3000	15	165
5000	18	250
10000	20	280
15000	25	300
20000	28	350
30000	30	400
50000	35	500
80000	45	600
100000	60	800
150000	75	900
200000	90	1 000
250000	110	1 200
350000	120	1 500

Tables for Q. no 4(a).

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Table 4. Propeller works (fixed pitch) – 1

(a) Disconnecting and removing propeller cone, removing propeller nut, setting up ship's withdrawing gear, rigging and withdrawing propeller and landing in dock bottom. On completion, rigging and refitting propeller as before and tightening to instructions of owner's representative. Excluding all removals for access, any other work on propeller and assuming no rudder works

(b) Transporting propeller to workshops for further works and returning to dock bottom on completion

Shaft dia. (mm)	*Man-hours*	
	(a)	*(b)*
Up to 100	20	15
100–200	30	18
200–300	45	25
300–400	60	30
400–800	90	60
800–900	150	100

Table 5. Anodes on hull and in sea chests

Weight (kg)	*Man-hours*
3	1
5	1
10	1.5
20	2

Table 6. Hollow fenders in half schedule 80 steel pipe

Pipe dia. (mm)	*Man-hours per metre*	
	Straight run of fender	*Curved fender at corners*
200	20	30
250	2	32
300	24	34
350	26	36

Table 7. Anchor cables (per side)

Small vessels

Cable dia. (mm)	*Man-hours (per side)*
< 25	70
25–50	90

Large cargo vessels and oil tankers

DWT	*Man-hours (per side)*
< 20000	100
20000–50 000	130
50000–100 000	140
100000–200 000	200
200000–300 000	250
over 300000	270

Tables for Q. no. 4(a)

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Table 8. Chain lockers (per side)

Small vessels

Cable dia. (mm)	*Man-hours (per side)*
< 25	70
25–50	90

Large cargo vessels and oil tankers

DWT	*Man-hours (per side)*
< 20000	100
20000–50 000	130
50000–100 000	140
100000–200 000	200
200000–300 000	250
over 300000	270

Tables for Q. no. 4(a).

❖ **Table** Steel works renewals

Plate thickness (mm)	*Man-hours per tonne*
Up to 6	250
8	245
10	240
12.5	230
16	220
18	210
20	200

Correction for curvature	*Factor increase*
Single	1.2
Double	1.3

Correction for location – external	*Factor increase*
Flat vertical side above 2 metres in height and requiring staging for access	1.1
Bottom shell, accessible areas (i.e. no removals of keel blocks)	1.12
Keel plate	1.4
Garboard plate	1.25
Bilge strake	1.25
Deck plating	1.15

Correction for location – internal	*Factor increase*
Bulkhead	1.2
Longitudinal/transverse above DB areas	1.25
Longitudinal/transverse below DB areas	1.35

Other adjustment factors	*Man-hour adjustment*
For fairing works:	
Remove, fair and refit	80% of renewal price
Fair in place (if practicable)	50% of renewal price

Tables for Q. no. 4(b).

L-4/T-1/NAME **Date: 19/10/2019**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2018-2019

Sub: **NAME 419** (Motion and Control)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

Symbols have their usual meaning. Assume reasonable values for missing data (if any).

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Develop the non-dimensional form of manoeuvring equations. **(20)**

   (b) The hydrodynamic derivatives for a 180m long ship are given below: **(15)**

	Y'_v	Y'_r	N'_v	N'_r	m'
Without Skeg	-0.0116	-0.00298	-0.00264	-0.00166	0.00798
With Skeg	-0.0050	-0.00298	0.000	-0.00166	0.00798

Show that the ship without the skeg is unstable but addition of the skeg makes it stable. Determine the distance of the neutral point for the two cases, and find the relative distance the neutral point has shifted aft due to addition of the skeg.

2. (a) What is slamming? What are the kinematic conditions to be investigated during the study of slamming? **(15)**

   (b) Define the threshold velocity of ship. Show mathematically that the threshold velocity of a ship is dependent on the Froude number of the ship. **(10)**

   (c) The following values of a ship are given below: **(10)**

Length	L	121.95 m
Draft	T	7.62 m
Speed	V_s	20 knots
Wave Length	L_w	191.46 m
Wave Height	H_w	6.10 m
Heading Angle	μ	180^0 head sea

Determine whether or not forefoot of the ship emerges.

3. (a) Describe step by step calculation procedure of ship motion in an irregular seaway. **(17)**

   (b) Form an irregular wave record, the following statistical information could be found: **(18)**

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Contd... Q. No. 3(b)

Wave-height intervals (m)	Number of occurrences
0.25-0.75	15
0.75-1.25	30
1.25-1.75	54
1.75-2.25	22
2.25-2.75	15
2.75-3.25	9
3.25-3.75	4
3.75-4.25	1

Find the 1/3rd , 1/10th and 1/100th significant wave heights.

4. (a) Describe by suitable sketches different types of motion stability for a surface ship. (15)

(b) What are IMO standards criteria for ship maneuverability? (20)

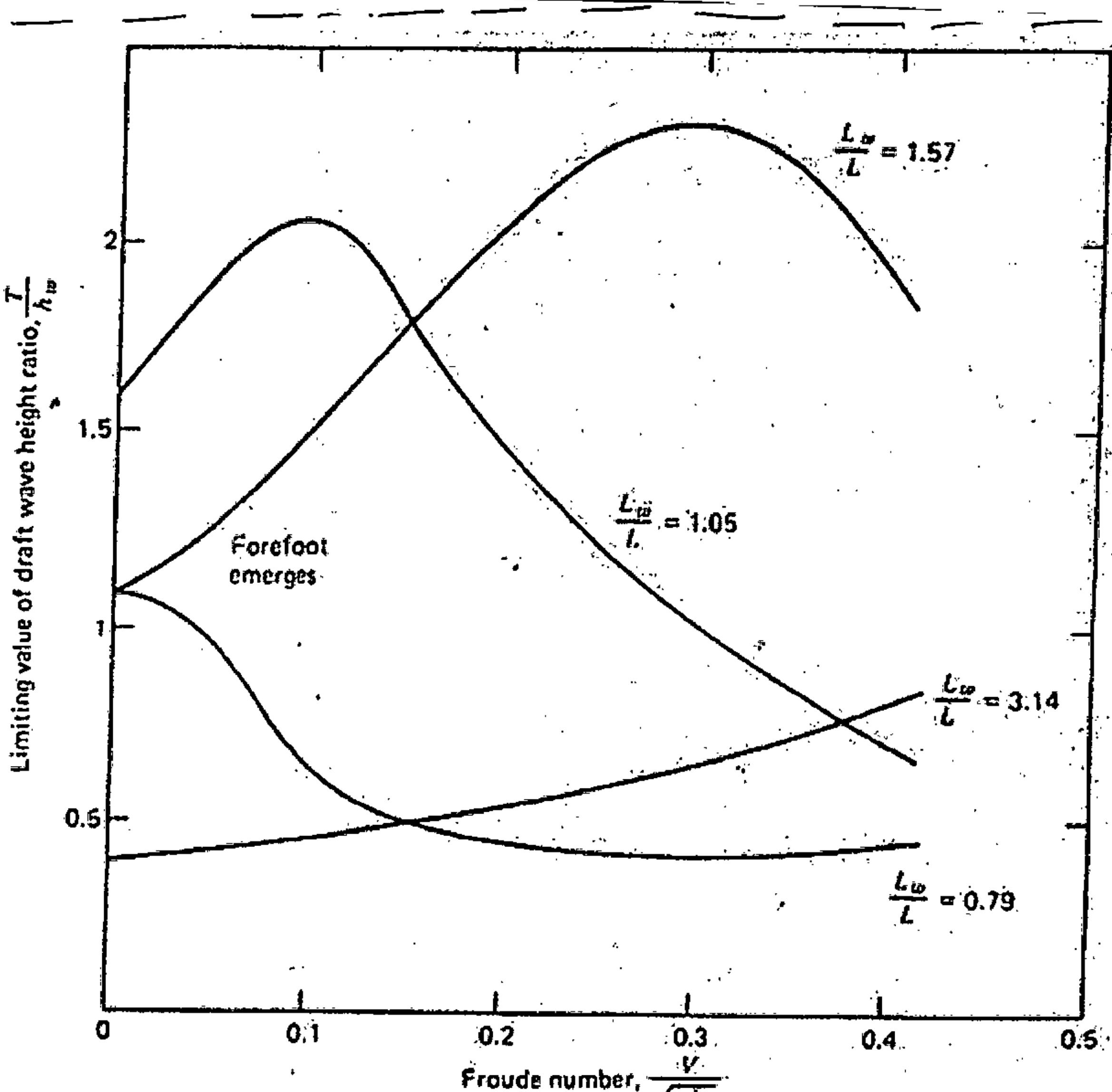

Figure for Question No. 2(c): Condition for Forefoot Emergence

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SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Consider a towing tank of length 150m with a wave-maker at one end. For a regular water wave of period 2 sec and amplitude 0.2m are being generated by the wave maker. Assume water depth is sufficiently high to consider the generated wave a deep water wave.

Determine: **(24)**

i) The circular frequency, wave number and wave length.

ii) The maximum horizontal and vertical fluid particle velocities.

iii) The path of fluid particle at the surface of the wave.

iv) The energy in the waves per unit surface area.

v) The path of fluid particle at 0.50m below the still water level.

vi) The maximum pressure at 0.50m below the still water level.

vii) The phase velocity and the group velocity.

viii) The time taken for the wave front to reach the other end of the tank.

(b) Define standing wave. Show that a combination of two standing waves out of phase by $\pi/2$ produces a progressive wave. **(11)**

6. (a) A model ship has the following particulars:

Length of model, $L_m = 19.20$ ft

Maximum Beam, $B_m = 2.592$ ft

Draft, $T_m = 1.144$ ft

Longitudinal C.G. (LCG) = + 0.48ft forward of amid ship;

Longitudinal C.B. (LCB) = + 0.48 ft forward of amid ship

Model speed $u_m = 4.788$ ft/sec

Displacement $\Delta_m = 2837.76$ lb, $\rho = 1.94$ lb-sec^2/ft^4

Consider the wavelength is equal to ship-model length and direction of travel 180 degree. The model has the following data: **(25)**

St.No.	B_n(ft)	T_n (ft)	S_n (ft^2)
0	0	1.144	0
5	2.592	1.144	2.944
10	2.592	1.144	2.944
15	2.592	1.144	2.752
20	0	1.144	0

Find the added mass for heaving in terms of model mass. Also find the restoring force Co-efficient for heaving for the above-mentioned model.

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Contd... Q. No. 6

(b) Define the following terms: **(10)**

Ahead seas, overtaking seas, following seas, subcritical zone and supercritical zone.

7. (a) A ship has the following particulars:

$L = 137.16m$ $B = 21.336m$ $GM_L = 137.16m$

$\mu = 180^0$, $C_{wp} = 0.80$ k_{yy}=33.53m, $\rho = 1030 kg/m^3$

The ship has a displacement of 12700 MT which moves head sea against 6.096 m high waves that have 5.32 sec encountering period.

Assume the added mass of inertia to be 54% of the mass moment of inertia of the ship and the non-dimensional damping coefficient of pitching motion is

$$\frac{b\sqrt{gL}}{\Delta L^2} = 0.154$$

Again the non-dimensional amplitude of the pitching moment is **(25)**

$$f_0 = \frac{M_o}{\frac{1}{2}pg\xi_a L^2 B} = 0.25$$

Find: i) amplitude for pitching motion

ii) Phase difference between pitching and wave motions

(b) Given:

$T\phi = 15sec$

V= 35 knots

$L_w = 900ft$ **(10)**

Determine the heading of the ship relative to the waves when the largest rolling would be expected.

8. (a) Write the expression for undamped natural periods of heave, roll and pitch motions. Also determine the scale factors for these natural periods between model and prototype. **(10)**

(b) The equation of rolling motion of a ship is expressed as: **(25)**

$$\frac{d^2\varphi}{dt^2} + 0.0724\frac{d\varphi}{dt} + 0.164\varphi = \alpha'_M w_\phi^2 \sin wet$$

If the maximum effective wave-slope α'_M can be considered to be a constant, namely $\frac{\pi}{20}$ rad, for a certain encountering frequency of 0.20 rad/sec, show that the natural oscillations will gradually disappear with time (Take t = 0 to t = 90 sec, with interval of 15 sec) while the amplitude of the forced oscillations will remain un-affected. The initial conditions specified are as follows:

Both $\varphi = 0$ and $\frac{d\varphi}{dt} = 0$ when $t = 0$

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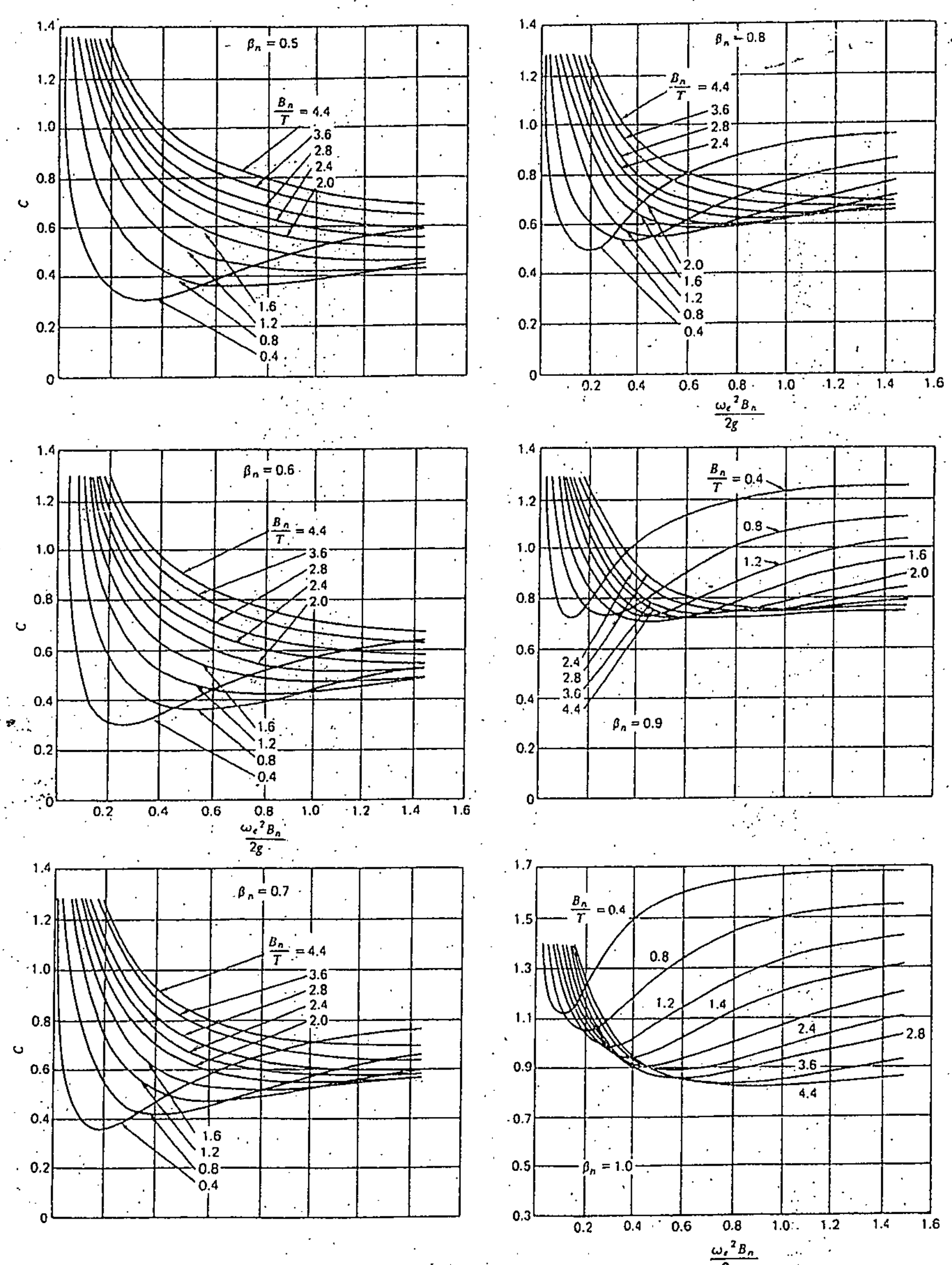

Fig. for Q. No. 6(a)

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L-4/T-1/NAME Date : 06/11/2019

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2018-2019

Sub : **NAME 439** (Ship Vibration)

Full Marks : 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

Symbols have their usual meaning. Reasonable values can be assumed for any missing data.

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Derive Schilick's formula for the natural period of vibration of ship. What are the limitations of Schilick's formula? Discuss the advantage of Todd formula over Schilick's formula. **(25)**

(b) The frequency of vertical vibration of a ship 420 ft in length having a displacement of 12,500 tones is 78 cycles per minute. The moment of inertia of the midship section is 3,40,000 $in^2.ft^2$. Determine the frequency of vibration of a ship similar type 450 ft in length, displacement 15,000 tones and a midship section moment of inertia of 4,70,000 $in^2.ft^2$. **(10)**

2. (a) What is free-free beam? Show that for a simple prismatic beam of constant cross-section and weight per unit length, the transverse natural frequency can be expressed **(25)**

$$f = \frac{(ml)^2}{2\pi}\sqrt{\frac{EIg}{\omega l^3}}$$

where the symbols have their usual meaning.

(b) Explain what do you mean by 'virtual weight factor', regarding calculation of ship's natural hull frequency? **(10)**

3. (a) Prove that the virtual mass effect is present only in the case of accelerated motion. **(15)**

(b) Discuss technically five cases of incidents that involved major ship accident due to vibration in ship. **(20)**

4. (a) A ship of dimension 450 ft × 60 ft ×32 ft has the draft 26 ft. and block coefficient 0.735. Assume that the maximum bending moment is given by WL/20 ft-ton, the maximum stress due to bending 7 $tons/in^2$ and the neutral axis is 6 ft above the keel. Determine the frequency of vibration by Schilick's formula (ϕ = 128,000) and Burrill's formula (ϕ = 200,000). **(20)**

(b) A ship of length 134 m, breadth 19.7 m and draft 7.58 m has a displacement of 15,600 tonnes. The moment of inertia is 364,000 $m^2.cm^2$. Determine the natural frequency of vibration allowing entrained water. The constant can be taken as 24,000. **(15)**

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SECTION – B

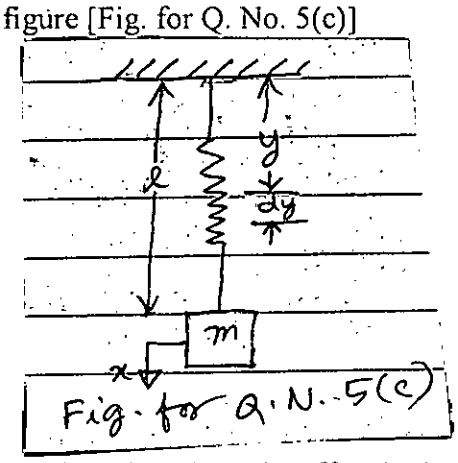
There are **FOUR** questions in this Section. Answer any **THREE**.

Symbols have their usual meaning. Reasonable value can be assumed for any missing data.

5. (a) How can you differentiate longitudinal and transverse vibration of ships? **(15)**

(b) Write down a summary of check list that is to be encountered in typical concept design process. **(10)**

(c) Determine the effect of the mass of the spring on the natural frequency of the system shown in the following figure [Fig. for Q. No. 5(c)] **(10)**

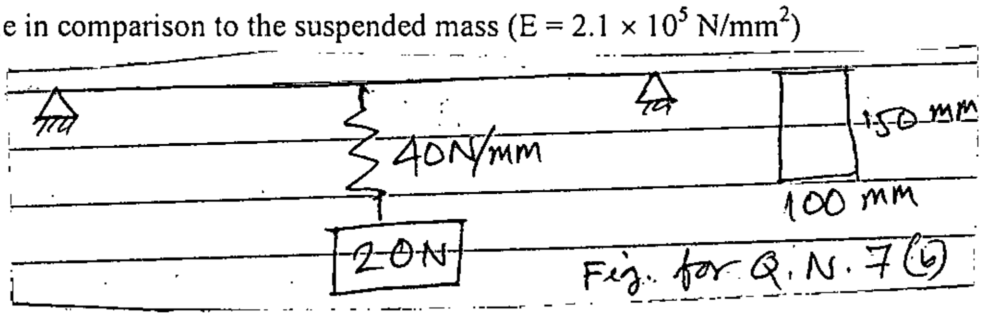


6. (a) What is damping? How does damping take effect in dry surfaces and lubricated surfaces? **(13)**

(b) Derive the general expression of frequency and vertical displacement of the natural vibration of a spring-mass system without damping. **(22)**

7. (a) Deduce mathematically the natural vibration with viscous damping of spring mass system with reference to Under damping system (n<p), over damped system (n>p) and critically damped system. What do you mean by logarithmic decrement? **(25)**

(b) Find natural frequency of the system shown in Fig. for Q. No. 7(b). The mass of the beam is negligible in comparison to the suspended mass ($E = 2.1 \times 10^5$ N/mm^2) **(10)**



8. (a) Write short notes on magnification factor and beating phenomenon. **(12)**

(b) A thin plate of area, A and weight, w is attached to the end of a spring and is allowed to oscillate in a viscous fluid. If τ_1 is the natural period of undamped oscillation (i.e., with the system oscillating in air) and τ_2 the damped period with the plate immersed in the fluid. Show

that $\mu = \dfrac{2\pi\omega}{gA\tau_1\tau_2}\sqrt{\tau_2^2 - \tau_1^2}$

where the damping force on the plate is Fd = 2A μv, 2A is the total surface area of the plate and v is its velocity. **(10)**

(c) Explain different types of degree of freedom with necessary figure and examples. **(13)**

L-4/T-1/NAME Date : 29/10/2019

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B.Sc. Engineering Examinations 2018-2019

Sub : **NAME 451** (Advanced Ship Structure)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) Briefly discuss major factors influencing environment-assisted fracture. **(12)**

(b) Distinguish between constant amplitude fatigue and variable amplitude fatigue load. How does a fatigue crack get initiated on a smooth surface? **(10)**

(c) What is crack closure? Why does it happen? **(7)**

(d) Write a short note on S-N curve. **(6)**

2. (a) State and prove Castigliano's first theorem for deflection. Also mention the limitations of this theory. **(15)**

(b) Using Castigliano's first theorem, obtain the expression for (i) the deflection under a single concentrated load applied to a simply supported beam as shown in Fig. for Q. No. 2(b), (ii) the deflection at the centre of a simply supported beam carrying a uniformly distributed load. **(20)**

3 (a) With necessary assumption derive Perry-Robertson formula. **(15)**

(b) Two 300 mm × 120 mm I-section joists are united by 12 mm thick plates as shown in Fig. for Q. No. 3(b) to form a 7 m long stanchion. Given a factor of safety of 3, a compressive yield stress of 300 MN/m^2 and a constant a of 1/7500, determine the allowable load which can be carried by the stanchion according to the Rankine-Gordon formulae. **(20)**

4. (a) Derive the expression for maximum deflection and maximum bending moment for a laterally loaded strut with uniformly distributed load. **(20)**

(b) A hollow circular steel strut with its ends fixed in position has a length of 2 m, an outside diameter of 100 mm and an inside diameter of 80 mm. Assuming that, before loading, there is an initial sinusoidal curvature of the strut with a maximum deflection of 5 mm, determine the maximum stress set up due to compressive end load of 200 kN. ($E = 208\ GN/m^2$) **(15)**

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

Symbols have their usual meanings. In case of missing data, assume reasonable value.

5. (a) Mention some common causes of failure of a structural component. **(7)**

(b) Describe brittle and ductile fractures. **(10)**

(c) Explain Griffith's dilemma, realization and analysis regarding crack growth. **(18)**

Contd P/2

NAME 451
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6. (a) How does the rate of change of strain energy give 'G' for constant load case or constant displacement case? How does the rate of change of compliance give 'G' for constant load case or constant displacement case? **(15)**

(b) Determine the shape of the DCB specimen as shown in Figure for Q. No. 6(b) if 'G_I' is to remain constant with the growth of the crack. The specimen is loaded in the constant load mode. Determine the depth 'h' of the specimen beyond the crack tip if thickness of the specimen remains constant (B = 30 mm). The initial crack length is 50 mm, modulus 207 GPa and depth of each cantilever 12 mm up to the initial crack length. **(10)**

(c) Determine the energy release rate for an edge crack loaded as shown in Figure for Q. No. 6(c). **(10)**

7. (a) Why is it necessary to evaluate SIF for a crack in a component? How does it help a designer? **(15)**

(b) A portion of a long beam is designed to a maximum stress of 32,000 psi and it is loaded in the manner shown in Figure for Q. No. 7(b). The L/w ratio is 4, with B and w dimensions specified as 0.5 and 2.5 inch respectively. Estimate the maximum allowable depth of the edge crack not to exceed the stress intensity of 38.5 MPa $(m)^{1/2}$. **(20)**

8. (a) Write down the Westergaard function for a center crack in an infinite plate subjected to a bi-axial stress filed and show that the function satisfies the boundary conditions. **(15)**

(b) Derive the stress field expression for a general point near the crack tip for isotropic and linear elastic material in an infinite flat plate subjected to a bi-axial stress field for Mode I case. **(20)**

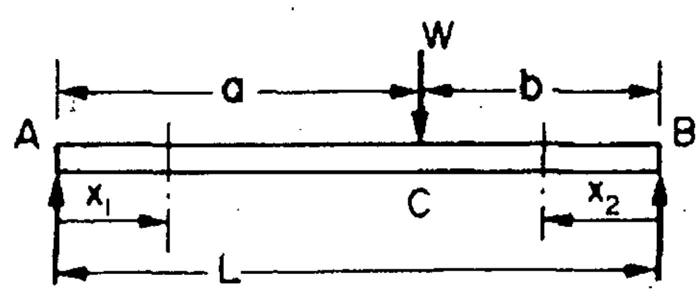

Fig. for Q. No. 2(b)

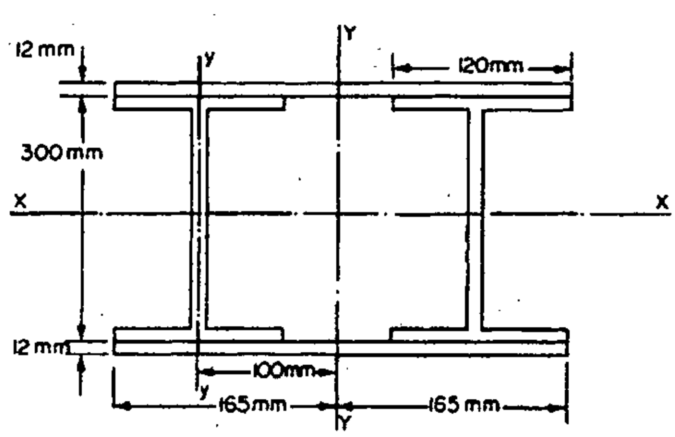

Fig. for Q. No. 3(b)

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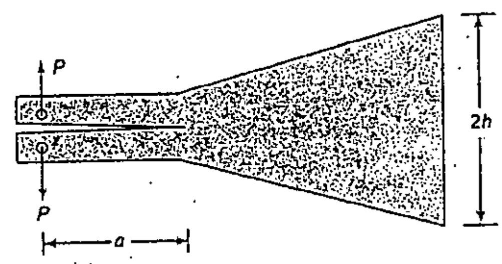


Figure for Q. No. 6(b)

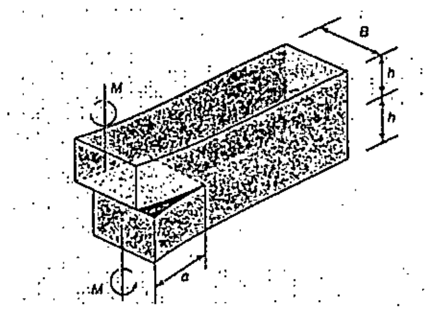
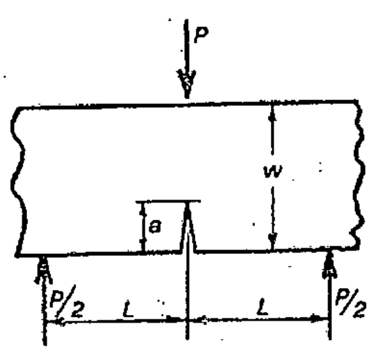
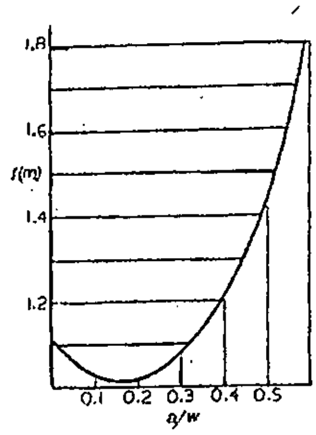


Figure for Q. No. 6(c)



(i)



(ii)

Figure for Q. No. 7(b)

—X—

 Date : 29/10/2019

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2018-2019

Sub : **NAME 477** (Optimization Methods in Ship Design)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) State the optimality and feasibility conditions for Dual simplex method. **(7)**

(b) Write the dual of the following primal problem

Maximize $z = x_1 + x_2$ **(8)**

Subject to

$$2x_1 + x_2 = 5$$
$$3x_1 - x_2 = 6$$
$$x_1,\ x_2 \text{ Unrestricted.}$$

(c) Solve the following problem by the Dual simplex method. **(20)**

Minimize $z = 4x_1 + 2x_2$

Subject to

$$x_1 + x_2 = 1$$
$$3x_1 - x_2 \geq 2$$
$$x_1, x_2 \geq 0$$

To apply the dual simplex method, replace the equality constraints with two inequalities.

2. (a) Derive an expression for the constraint gradient vector for f(y, z) with respect to z. **(15)**

(b) Solve the following LP by the Jacobian method. **(20)**

Maximize $z = 2x_1 + 3x_2$

Subjected to

$$x_1 + x_2 + x_3 = 5$$
$$3x_1 - x_2 + x_4 \geq 3$$
$$x_1, x_2, x_3, x_4 \geq 0$$

3. (a) Write the Karush-Khun-Tucker conditions for the following problem **(15)**

Maximize $z = x_1^3 - x_2^2 + x_1 x_3^2$

Subjected to

$$x_1 + x_2^2 + x_3 = 5$$
$$5x_1^2 - x_2^2 - x_3 \geq 0$$
$$x_1, x_2, x_3 \geq 0$$

Contd P/2

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(b) Solve the problem by the Lagrangean method **(20)**

Minimize $z = x_1^2 + x_2^2 + x_3^2$

Subjected to

$$4x_1 + x_2^2 + 2x_3 - 14 = 0$$
$$x_1, x_2, x_3 \geq 0$$

4. (a) Determine the stationary points for the functions **(15)**

$$f(x) = 5x^6 - 36x^5 + \frac{165}{2}x^4 - 60x^3 + 36$$

and then classify them w.r.t. global maxima/local maxim`a/saddle points.

(b) Solve the NLP by Sequential Linear Programming **(20)**

Maximize $z = x_1^4 - 2x_1^2x_2 + x_1^2 + x_1x_2^2 - 2x_1 + 4$

Subjected to

$$x_1^2 + x_2^2 - 2 = 0$$
$$0.25x_1^2 + 0.75x_2^2 - 1 \leq 0$$
$$0 < x_1 \leq 5;\ 0 < x_2 \leq 5$$

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

(Symbols have their usual meaning)

5. (a) Consider the following Linear Programming (LP) (25)

Maximize $z = 2X_1 + 3X_2$

Subjected to

$$X_1 + 3X_2 \leq 6$$
$$3X_1 + 2X_2 \leq 6$$
$$X_1, X_2 \geq 0$$

(i) Express the problem in standard form

(ii) Determine all the basic solutions of the problem and classify them as feasible and infeasible.

(iii) Determine the optimum solution using direct substitution in the objective function.

(b) Explain the term degeneracy, alternative optima and unbounded solution. (10)

6. (a) State the optimality and feasibility conditions of the Simplex method. (10)

(b) Consider the following Linear Programming (LP)

Maximize $z = 4X_1 + X_2$

Subjected to

$$3X_1 + X_2 = 3$$
$$4X_1 + 3X_2 \geq 6$$
$$X_1 + 2X_2 \leq 4$$
$$X_1, X_2 \geq 0$$

The optimum simplex tableau at the end of phase I is given as

Contd P/3

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Contd....Q. No. 6(b)

Basic	X_1	X_2	X_3	R_1	R_2	X_4	Solution
r	0	0	0	-1	-1	0	0
X_1	1	0	1/5	3/5	-1/5	0	3/5
X_2	0	1	-3/5	-4/5	3/5	0	6/5
X_4	0	0	1	1	-1	1	1

Determine the solution of the original problem from phase I.

7. (a) How does Genetic Algorithm (GA) differ from the traditional methods of optimization? **(10)**

   (b) Solve the following unconstrained optimization problem by Particle Swarm Optimization (PSO) method. **(25)**

   Maximize $z = X^2 + 2X + 11$ with $-2 < X < 2$

   Use four particle (N = 4) with initial position $X_1 = -1.5$, $X_2 = 0.0$ $X_3 = 0.5$ and $X_4 = 1.25$. Show the detail computations for iterations 1 and 2.

8. (a) What is Integer Linear Programming (ILP)? How can you classify it? **(5)**

   (b) Solve the following Integer Linear Programming (ILP) by cutting plane algorithm

   Maximize $Z = 7X_1 + 10X_2$ **(30)**

   Subject to

   $$-X_1 + 3X_2 \leq 6$$
   $$7X_1 + X_2 \geq 35$$
   $$X_1, X_2 \geq 0 \text{ and integer}$$

   Given the slacks X_3 and X_4 for the constraint 1 and 2, the optimum LP tableau is

Basic	X_1	X_2	X_3	X_4	Solution
Z	0	0	63/22	31/22	133/2
X_1	1	0	-1/22	3/22	9/2
X_2	0	1	7/22	1/22	7/2

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2018-2019

Sub : **NAME 475** (Dredger and Dredging Technology)

Full Marks : 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

Symbols have their usual meaning. Assume reasonable value of any missing data.

1. (a) Define the following terms: Bulking factors, Dead time, DMMS, Dike. **(11)**

   (b) Which types of dredger/dredgers will you recommend for dredging each of the following types of soil? **(24)**

   (i) sand and non-cohessive silts.

   (ii) Clay and co-hesive silts.

   Justify your answer with respect to their dredging operation for the above mentioned types of soils.

2. (a) Mention the salient features of Centrifugal Dredge pump. Schematically show the comparison of performance curves between a centrifugal pump pumping slurry and a centrifugal pump pumping clear water. **(12)**

   (b) For designing a Trailing Suction Hopper Dredger, the following data are available:

   Yearly dredge output = 5 M m^3

   Type of material: Coarse sand and gravel (ρ = 2000 kg/m^3)

   Distance of the site: 75 Nautical miles

   Ship speed: 15 knot

   Dredger working hour: 5 days at 24 hours, Overhaul 2 weeks, Weather delay 3 weeks, Christmas 1 week, Bunkers will be taken in the weekend.

   Loading and unloading time: 3 hours

   Sailing to the unloading area: 3 hours

   Max^m. Filling of hopper = 90% Workability 95%

   Calculate the required hopper volume and hopper density. **(8)**

   (c) Briefly discuss different types of transport for the dredge material. **(15)**

3. (a) Write short notes on: **(20)**

   (i) Excavation of rock without pre-treatment

   (ii) Floating pipelines of dredger

   (iii) Bucket dredger

   (iv) Amphibious dredger

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Contd ... Q. No. 3

(b) A dredging pipeline is designed to transport 70 tons of sand per hour. The specific gravity of the sand particle is 2.65. The concentration by weight is 30%. Determine the density of the mixture if the carrier fluid is water. Find also the concentration of solid by volume. **(10)**

(c) Suppose actual slurry mixture velocity is found 8.6 ft/sec for the above mentioned problem of Q. No. 3(b) for a 6 inch dia pipeline. Is this pipe is suitable for the application? Justify your answer by calculation. Consider $F_L = 1.04$. **(5)**

4. (a) The centerline of a dredge pump is loaded 2 ft below the water level. The cutter head dredger is operating in 15 ft of water and has a 30 ft suction pipe and 200 ft discharge pipe and each pipe has a diameter of 4″. The channel bottom material is sand (median diameter of sand = 0.08″) and water has specific gravity 1.0 and average temperature 70°F. The other available data are: **(25)**

$C_w = 40\%$, $F_L = 1.3$, $f = 0.0142$

Estimated terminal settling velocity $V_s = 0.95$ ft/sec

Estimated drag coefficient $C_D = 0.4$

For delivery of 0.363 ft^3/sec sand, determine:

(i) Limiting deposit velocity

(ii) Transition velocities for different regimes of flow

(iii) Head loss per unit length of pipeline

(iv) Friction head loss neglecting minor losses.

(b) Explain why booster pump is used for dredging operation. **(4)**

(c) What is critical velocity? Mention why it is important for slurry transportation. **(6)**

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) Define dredging. Explain the terms: Capital dredging and maintenance dredging. **(6)**

(b) Mention the factors for selecting dredging equipment of any project. **(5)**

(c) Briefly discuss the design of dredging works to determine the width, depth and bend of a navigational channel. **(15)**

(d) Why dredging is important for Bangladesh? What are the challenges for dredging in Bangladesh? **(9)**

6. (a) Give a brief description of physical mechanism involved in dredging process. **(18)**

(b) Draw the production cycle for pontoon mounted grab dredger. **(7)**

(c) Draw the main futures of pontoon mounted grab dredger. **(5)**

(d) Discuss various types of rope operated grab buckets. **(5)**

Contd P/3

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7. (a) What is Trailing suction Hopper Dredger (TSHD)? What are the advantages and disadvantages of using a TSHD? **(10)**

   (b) With neat sketches distinguish between fixed and adjustable overflow systems in a trailing suction hopper dredger (TSHD). **(10)**

   (c) What is the function of a draghead? Name various types of draghead with their application. **(7)**

   (d) Briefly discuss various methods of discharging hoppers for a TSHD. **(8)**

8. (a) With neat sketch show main features of a CSD. **(10)**

   (b) Why spud system plays an important role on the design of CSD? Briefly describe the spud carriage system in CSD. **(10)**

   (c) With neat sketches explain under cutting and over cutting for a dredger. **(5)**

   (d) Distinguish between the followings: **(10)**

   (i) Draghead and Cutting heed

   (ii) Shore pipeline and floating pipeline.

Contd... P/4

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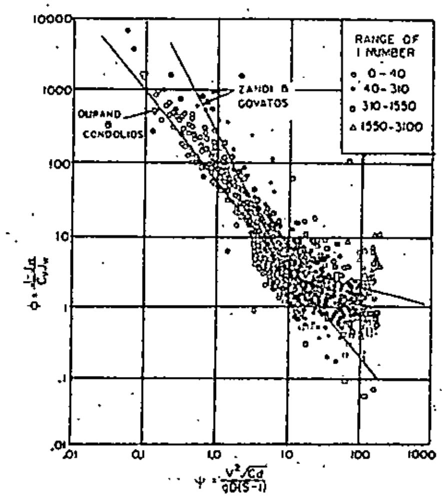

Figure 9.8. Head loss in heterogeneous flow—after Zandi and Govatos.

Table 9.5. Limiting Deposit Velocity for Particles Greater Than 1mm in Diameter (Ref. 12)

Pipe Diameter (d) (mm)	Limiting Deposit Velocity Sand m/sec	Coal m/sec
150	2.95	1.65
250	3.75	2.15
440	5.00	2.85
900	7.15	4.00

Durand and Condolios[25] presented an equation for flow based on test results as follows

$$\frac{i_m - i}{C_v i} = 81\left[\frac{gd\,(\rho_s/\rho_w - 1)}{V^2}\left(\frac{1}{C_D}\right)\right]^{1.5} \qquad 9.19$$

Newitt et al.,[14] conducted an experiment in a smaller size pipe (1 inch) with several sediments ranging from plastics to gravel and manganese dioxide. They suggested the Equation 9.20 for heterogeneous flow.

$$(i_m - i)/(C_V i) = 1100\,[(\rho_s/\rho_w) - 1]\,(gd/V^2)\,(V_t/V) \qquad 9.20$$

where

V_t = particle settling velocity.

Contd...P/5

 P-1/2

For saltation flow (for particle $d_{50} > 0.001$ in.)

$$(i_m - i)/(C_v i) = 66\,[(\rho_s/\rho_w) - 1]\,(gd/V^2) \qquad 9.21$$

The transition zone between homogeneous and heterogeneous regimes is given as

$$V_{th} = (1800\,gdV_t)^{1/3} \qquad 9.22$$

where

V_{th} = transition velocity from homogeneous to heterogeneous regime

Transition zone between heterogeneous and saltation region is given as

$$V_{ts} = 17\,V_t \qquad 9.23$$

where

V_{ts} = transition velocity from heterogeneous to saltation regime

Worster[3] presented the flow equations based on work by Turtle:

$$\frac{C_c - C'_c}{g} = 4\left(\frac{V_t}{V}\right)^{0.173}\frac{C_c}{\sqrt{g}}\left[\frac{C_v\,d\,g(\rho_s/\rho_w - 1)}{V^2}\right]^{0.413} - 4 \qquad 9.24$$

where

C_c = Chezy friction factor for water
C_c' = Chezy friction factor for mixture

which applies when

$(C_c - C_c')/\ 1/\sqrt{g} < 13$

Wilson[26] proposed an equation for friction head loss in feet of slurry based on data obtained on pumping molybdenum tailings in Colorado.

$$h_f' = L\left(\frac{fV^2}{2gd} + C_1\frac{C_w V_t}{V}\right) \qquad 9.25$$

where

f = Darcy Weisbach friction factor
C_1 = Constant

= 4 =

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P-2/2

The velocity (in fps) which produces a minimum friction loss for given conditions is

$$(V_{hf})_{min} = C_2 \sqrt[3]{(C_w V_t g d)/f} \qquad 9.26$$

where

K_2 = constant

Wilson also presented Equation 9.27 which gives a guide as to whether particles are suspended in flowing water or whether they will settle to form a bed at the bottom of the pipe.

$$C_3 = \frac{V_t}{\sqrt{(h'_f g d)/4L}} \qquad 9.27$$

when $C_3 > 1$ most of the particles with terminal velocity (V_t), will stay in suspension and when $C_3 \leq 1$ most of the particles with terminal velocity (V_t) will settle out.

Zandi and Govatos[15] in an effort to separate experimental data for the heterogeneous regime from the saltation flow developed an Index Number (N_I).

$$N_I = \frac{V^2\sqrt{C_d}}{C_v d g \;[(\rho_s - \rho_w)/\rho_w]} \qquad 9.28$$

The critical value of N_I indicates the separation of the two flow regimes, i.e.

$$(N_I)_{critical} = 40 \qquad 9.29$$

The saltation flow occurs for $N_I<40$ and the heterogeneous regime for $N_I>40$.

Babcock and Shaw using Blatch's data[27] concluded that N_I should be equal to ten for separation of the heterogeneous and moving bed regimes. Additional experimental verifications are required.

Modified Durand Equation (by Zandi)

Zandi analyzed Durand's data which were selected on the basis of the Index Number (N_I); only those data points which were in the heterogeneous regime were selected for analysis. Zandi points out that

$$N_I = \frac{1}{C_v}\left[\frac{V^2\sqrt{C_d}}{g d\left(\frac{SG_s - SG_w}{SG_w}\right)}\right] = \frac{\psi}{C_v} \qquad 9.30$$

For Q. No. 4(a)

and

$$\phi = \frac{J - J_w}{C_v - J_w} = K(\psi)^m \qquad 9.31$$

where both K and m are coefficients shown in Table 9.6.

Durand's reanalyzed data are plotted in Figure 9.8 as ϕ versus ψ. Note that better correlation of all values of ψ is achieved if ψ is divided into two separate ranges, for $\psi > 10$ and for $\psi < 10$ as indicated in Table 9.6.

Table 9.6. Values of Coefficient *K* and *m* in Equation 9.31

Range of ψ	K	m
$10 < \psi$	6.3	−0.354
$\psi < 10$	280.0	−1.93

Blockage of Pipe

In some cases it may be desirable to design for solids transport in the moving bed regime or such flows may be the result of insufficient power. Many designs call for no settlement of sediment (heterogeneous regime) but under certain conditions it may be economically desirable to permit some settlement resulting in partial blockage of the cross sectional pipe area. The partial blockage occurs when the rate of sediment supply to the pipe exceeds the transporting capacity of the water. The sediment will deposit at the bottom of the pipe until an equilibrium condition is reached when the cross sectional area is sufficiently reduced to provide sufficient transporting capacity.

Craven[28] conducted studies in 2-inch and 5.5-inch diameter pipes, with three approximately uniform sands having median diameters of 0.25, 0.58 and 1.62 mm respectively, to determine blockage characteristics. He determined that for relatively high values of relative transport rate (Q_s/Q) Darcy's hydraulic gradient (i) was proportional to the two-thirds power of Q_s/Q, as shown in Equation 9.32.

$$i = (dh/dx) = C_3 (Q_s/Q)^{2/3} \qquad 9.32$$

where

Q_s = absolute rate of sediment transport
C_3 = constant
$= 1/1.65[(\gamma_s - \gamma_w)/\gamma_w]$ for 0.58 and 1.62 mm sands
$= 0.6/1.65[(\gamma_s - \gamma_w)/\gamma_w]$ for 0.25 mm sand.

"5"

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L-4/T-1/NAME **Date : 24/10/2019**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2018-2019

Sub : **IPE 479** (Engineering Management)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Define Production Planning and Control. Explain the processes involved in Production Planning and Control system. **(15)**

(b) Explain 'Discrete manufacturing' and 'Process manufacturing'. **(10)**

(c) What are the functions of shop floor control? **(10)**

2. (a) What are the assumptions of basic EOQ mode? When and why is production order quantity model used? Prove that optimum production quantity **(15)**

$$Q^* = \sqrt{\frac{2DS}{H[1-d/p]}}$$

where the symbols carry their usual meaning.

(b) A local distributor for a national tire company expects to sell approximately 9600 steel belted radial tires of a certain size and tread design next year. Annual carrying cost is $16 per tire, and ordering cost is $75. The distributor operates 288 days per year. **(20)**

(i) Calculate EOC%

(ii) How many times per year does the store reorder?

(iii) What is the length of an order cycle?

(iv) What is the total annual cost if the EOQ is ordered?

3. (a) What is the feasible solution in linear programming? Explain with an example. **(10)**

(b) Why layout decisions are important in a facility? "Product layout is suitable for large volume production whether process layout is for batch production"-justify this statement. **(10)**

(c) Like all things, there is a price to pay for a quality- 'for achieving it', as well as 'for losing it' also. Explain this statement. **(15)**

4. (a) Which theories have been development to overcome the limitations of F.W. Taylor's philosophy? **(5)**

(b) What is Hawthorne effect and why is it important to managers? **(3×10=30)**

(c) Compare and contrast early theories of motivation.

Contd P/2

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) Write down the typical capital budgeting decisions. **(5)**

(b) Under a special licensing arrangement, '**X**' Corporation has an opportunity to market a new product for a five-year period. The product would be purchased from the manufacturer, with '**X**' responsible for promotion and distribution costs. The licensing arrangement could be renewed at the end of the five-year period. After careful study, '**X**' estimated the following costs and revenues for the new product: **(20)**

Cost of equipment needed		$120,000
Working capital needed		$80,000
Overhaul of equipment in	5 years	$40,000
Salvage of the equipment in	10 years	$20,000
Annual revenues and costs:		
Sales revenues		$245,000
Cost of goods sold		$160,000
Out-of-pocket operating costs		$50,000
Discount rate		14%

All the end of the five year period, if 'X' decides not to renew the licensing arrangement, the working capital would be released for investment elsewhere.

(i) What is the net present value of the project?

(ii) Experiment with changing the discount rate in one percent increment (e.g., 13%, 12%, 15%, etc). At what interest rate does the net present value turn from negative to positive?

(iii) The internal rate of return is between what two whole discount rates (e.g., between 10% and 11%, between 11% an 12%, between 12% and 13% and 14%, etc.)?

(c) The Heritage Amusement Park would like would like to construct a new ride called the Sonic Boom, which the park management feels would be very popular. The ride would cost $450,000 to construct, and it would have a 10% salvage value at the end of its 15-year useful life. The company estimates that the following annual costs and revenues would be associated with the ride: **(10)**

Ticket revenues		$250,000
Less operating expenses:		
Maintenance.................	$40,000	
Salaries	90,000	
Depreciation.................	27,000	
Insurance....................	30,000	
Total operating expenses.........		187,000
Net operating income............		$ 63,000

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Contd. ...Q. No. 5(c)

Assume that the Heritage Amusement Park will not construct a new ride unless the ride provides a payback period of six years or less. Does the Sonic Boom ride satisfy this requirement?

6. (a) Six jobs are to be processed through a two-step operation. The first operation involves sanding and the second one paining. Processing times are as follows **(15)**

Job	Operation 1 (hours)	Operation 2 (hours)
A	10	5
B	7	4
C	5	7
D	3	8
E	2	6
F	4	3

Determine a sequence using Johnson's Rule that will minimize the total completion time. Find out the completion time and idle time of that sequence.

(b) Six architectural rendering jobs are waiting to be assigned at 'Bengal Architects'. The work times and due dates are given in the following table. The firm wants to determine the sequence of processing according to (1) SPT, and (2) EDD priority rules. **(15)**

Job	Job Processing Time (Days)	Job Due Date (Days)
A	6	22
B	12	14
C	14	30
D	2	18
E	10	25
F	14	34

(i) Find the sequence of the jobs using (1) SPT, and (2) EDD priority rules.

(ii) Calculate the average completion time, utilization, average number of jobs in the system and average job lateness for the two priority rules stated above.

(c) What are the four scheduling criteria? Explain. **(5)**

7. (a) Discuss any two qualitative methods of forecasting. **(10)**

(b) Mark Cottler owns a company that manufacturers sailboats. Actual demand for Mark's Sailboats during each session in 2006 through 2009 as follows: **(15)**

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Contd. ...Q. No. 7(b)

	Year			
Season	2006	2007	2008	2009
Winter	1,400	1,200	1,000	900
Spring	1,500	1,400	1,600	1,500
Summer	1,000	2,100	2,000	1,900
Fall	600	750	650	500

Mark has forecasted that the annual demand of the sailboats in 2010 will equal 5,600 sailboats. Using seasonal index model, what will be the demand level for Mark's sailboats in **Spring, Summer and Fall** of 2010?

(c) The number of transistors (in thousands) made at a plant in Japan during the past 5 years follows: **(9)**

Year	Transistors
1	140
2	160
3	190
4	200
5	210

Forecast the number of plants to be made in next year, using least square regression method.

8. (a) Discuss the factors that influence the amount of centralization and decentralization. **(15)**

(b) What are the differences between mechanistic and organic organization? **(10)**

(c) Write down the strengths and weaknesses of traditional organization decisions. **(10)**

Contd. P/5

Appendix 13B: Present Value Tables

EXHIBIT 13B-1

Present Value of $1; $\frac{1}{(1+r)^n}$

Periods	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%	21%	22%	23%	24%	25%
1	0.962	0.952	0.943	0.935	0.926	0.917	0.909	0.901	0.893	0.885	0.877	0.870	0.862	0.855	0.847	0.840	0.833	0.826	0.820	0.813	0.806	0.800
2	0.925	0.907	0.890	0.873	0.857	0.842	0.826	0.812	0.797	0.783	0.769	0.756	0.743	0.731	0.718	0.706	0.694	0.683	0.672	0.661	0.650	0.640
3	0.889	0.864	0.840	0.816	0.794	0.772	0.751	0.731	0.712	0.693	0.675	0.658	0.641	0.624	0.609	0.593	0.579	0.564	0.551	0.537	0.524	0.512
4	0.855	0.823	0.792	0.763	0.735	0.708	0.683	0.659	0.636	0.613	0.592	0.572	0.552	0.534	0.516	0.499	0.482	0.467	0.451	0.437	0.423	0.410
5	0.822	0.784	0.747	0.713	0.681	0.650	0.621	0.593	0.567	0.543	0.519	0.497	0.476	0.456	0.437	0.419	0.402	0.386	0.370	0.355	0.341	0.328
6	0.790	0.746	0.705	0.666	0.630	0.596	0.564	0.535	0.507	0.480	0.456	0.432	0.410	0.390	0.370	0.352	0.335	0.319	0.303	0.289	0.275	0.262
7	0.760	0.711	0.665	0.623	0.583	0.547	0.513	0.482	0.452	0.425	0.400	0.376	0.354	0.333	0.314	0.296	0.279	0.263	0.249	0.235	0.222	0.210
8	0.731	0.677	0.627	0.582	0.540	0.502	0.467	0.434	0.404	0.376	0.351	0.327	0.305	0.285	0.266	0.249	0.233	0.218	0.204	0.191	0.179	0.168
9	0.703	0.645	0.592	0.544	0.500	0.460	0.424	0.391	0.361	0.333	0.308	0.284	0.263	0.243	0.225	0.209	0.194	0.180	0.167	0.155	0.144	0.134
10	0.676	0.614	0.558	0.508	0.463	0.422	0.386	0.352	0.322	0.295	0.270	0.247	0.227	0.208	0.191	0.176	0.162	0.149	0.137	0.126	0.116	0.107
11	0.650	0.585	0.527	0.475	0.429	0.388	0.350	0.317	0.287	0.261	0.237	0.215	0.195	0.178	0.162	0.148	0.135	0.123	0.112	0.103	0.094	0.086
12	0.625	0.557	0.497	0.444	0.397	0.356	0.319	0.286	0.257	0.231	0.208	0.187	0.168	0.152	0.137	0.124	0.112	0.102	0.092	0.083	0.076	0.069
13	0.601	0.530	0.469	0.415	0.368	0.326	0.290	0.258	0.229	0.204	0.182	0.163	0.145	0.130	0.116	0.104	0.093	0.084	0.075	0.068	0.061	0.055
14	0.577	0.505	0.442	0.388	0.340	0.299	0.263	0.232	0.205	0.181	0.160	0.141	0.125	0.111	0.099	0.088	0.078	0.069	0.062	0.055	0.049	0.044
15	0.555	0.481	0.417	0.362	0.315	0.275	0.239	0.209	0.183	0.160	0.140	0.123	0.108	0.095	0.084	0.074	0.065	0.057	0.051	0.045	0.040	0.035
16	0.534	0.458	0.394	0.339	0.292	0.252	0.218	0.188	0.163	0.141	0.123	0.107	0.093	0.081	0.071	0.062	0.054	0.047	0.042	0.036	0.032	0.028
17	0.513	0.436	0.371	0.317	0.270	0.231	0.198	0.170	0.146	0.125	0.108	0.093	0.080	0.069	0.060	0.052	0.045	0.039	0.034	0.030	0.026	0.023
18	0.494	0.416	0.350	0.296	0.250	0.212	0.180	0.153	0.130	0.111	0.095	0.081	0.069	0.059	0.051	0.044	0.038	0.032	0.028	0.024	0.021	0.018
19	0.475	0.396	0.331	0.277	0.232	0.194	0.164	0.138	0.116	0.098	0.083	0.070	0.060	0.051	0.043	0.037	0.031	0.027	0.023	0.020	0.017	0.014
20	0.456	0.377	0.312	0.258	0.215	0.178	0.149	0.124	0.104	0.087	0.073	0.061	0.051	0.043	0.037	0.031	0.026	0.022	0.019	0.016	0.014	0.012
21	0.439	0.359	0.294	0.242	0.199	0.164	0.135	0.112	0.093	0.077	0.064	0.053	0.044	0.037	0.031	0.026	0.022	0.018	0.015	0.013	0.011	0.009
22	0.422	0.342	0.278	0.226	0.184	0.150	0.123	0.101	0.083	0.068	0.056	0.046	0.038	0.032	0.026	0.022	0.018	0.015	0.013	0.011	0.009	0.007
23	0.406	0.326	0.262	0.211	0.170	0.138	0.112	0.091	0.074	0.060	0.049	0.040	0.033	0.027	0.022	0.018	0.015	0.012	0.010	0.009	0.007	0.006
24	0.390	0.310	0.247	0.197	0.158	0.126	0.102	0.082	0.066	0.053	0.043	0.035	0.028	0.023	0.019	0.015	0.013	0.010	0.008	0.007	0.006	0.005
25	0.375	0.295	0.233	0.184	0.146	0.116	0.092	0.074	0.059	0.047	0.038	0.030	0.024	0.020	0.016	0.013	0.010	0.009	0.007	0.006	0.005	0.004
26	0.361	0.281	0.220	0.172	0.135	0.106	0.084	0.066	0.053	0.042	0.033	0.026	0.021	0.017	0.014	0.011	0.009	0.007	0.006	0.005	0.004	0.003
27	0.347	0.268	0.207	0.161	0.125	0.098	0.076	0.060	0.047	0.037	0.029	0.023	0.018	0.014	0.011	0.009	0.007	0.006	0.005	0.004	0.003	0.002
28	0.333	0.255	0.196	0.150	0.116	0.090	0.069	0.054	0.042	0.033	0.026	0.020	0.016	0.012	0.010	0.008	0.006	0.005	0.004	0.003	0.002	0.002
29	0.321	0.243	0.185	0.141	0.107	0.082	0.063	0.048	0.037	0.029	0.022	0.017	0.014	0.011	0.008	0.006	0.005	0.004	0.003	0.002	0.002	0.002
30	0.308	0.231	0.174	0.131	0.099	0.075	0.057	0.044	0.033	0.026	0.020	0.015	0.012	0.009	0.007	0.005	0.004	0.003	0.003	0.002	0.002	0.001
40	0.208	0.142	0.097	0.067	0.046	0.032	0.022	0.015	0.011	0.008	0.005	0.004	0.003	0.002	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000

EXHIBIT 13B-2

Present Value of an Annuity of $1 in Arrears; $\frac{1}{r}\left[1 - \frac{1}{(1+r)^n}\right]$

Periods	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%	21%	22%	23%	24%	25%
1	0.962	0.952	0.943	0.935	0.926	0.917	0.909	0.901	0.893	0.885	0.877	0.870	0.862	0.855	0.847	0.840	0.833	0.826	0.820	0.813	0.806	0.800
2	1.886	1.859	1.833	1.808	1.783	1.759	1.736	1.713	1.690	1.668	1.647	1.626	1.605	1.585	1.566	1.547	1.528	1.509	1.492	1.474	1.457	1.440
3	2.775	2.723	2.673	2.624	2.577	2.531	2.487	2.444	2.402	2.361	2.322	2.283	2.246	2.210	2.174	2.140	2.106	2.074	2.042	2.011	1.981	1.952
4	3.630	3.546	3.465	3.387	3.312	3.240	3.170	3.102	3.037	2.974	2.914	2.855	2.798	2.743	2.690	2.639	2.589	2.540	2.494	2.448	2.404	2.362
5	4.452	4.329	4.212	4.100	3.993	3.890	3.791	3.696	3.605	3.517	3.433	3.352	3.274	3.199	3.127	3.058	2.991	2.926	2.864	2.803	2.745	2.689
6	5.242	5.076	4.917	4.767	4.623	4.486	4.355	4.231	4.111	3.998	3.889	3.784	3.685	3.589	3.498	3.410	3.326	3.245	3.167	3.092	3.020	2.951
7	6.002	5.786	5.582	5.389	5.206	5.033	4.868	4.712	4.564	4.423	4.288	4.160	4.039	3.922	3.812	3.706	3.605	3.508	3.416	3.327	3.242	3.161
8	6.733	6.463	6.210	5.971	5.747	5.535	5.335	5.146	4.968	4.799	4.639	4.487	4.344	4.207	4.078	3.954	3.837	3.726	3.619	3.518	3.421	3.329
9	7.435	7.108	6.802	6.515	6.247	5.995	5.759	5.537	5.328	5.132	4.946	4.772	4.607	4.451	4.303	4.163	4.031	3.905	3.786	3.673	3.566	3.463
10	8.111	7.722	7.360	7.024	6.710	6.418	6.145	5.889	5.650	5.426	5.216	5.019	4.833	4.659	4.494	4.339	4.192	4.054	3.923	3.799	3.682	3.571
11	8.760	8.306	7.887	7.499	7.139	6.805	6.495	6.207	5.938	5.687	5.453	5.234	5.029	4.836	4.656	4.486	4.327	4.177	4.035	3.902	3.776	3.656
12	9.385	8.863	8.384	7.943	7.536	7.161	6.814	6.492	6.194	5.918	5.660	5.421	5.197	4.988	4.793	4.611	4.439	4.278	4.127	3.985	3.851	3.725
13	9.986	9.394	8.853	8.358	7.904	7.487	7.103	6.750	6.424	6.122	5.842	5.583	5.342	5.118	4.910	4.715	4.533	4.362	4.203	4.053	3.912	3.780
14	10.563	9.899	9.295	8.745	8.244	7.786	7.367	6.982	6.628	6.302	6.002	5.724	5.468	5.229	5.008	4.802	4.611	4.432	4.265	4.108	3.962	3.824
15	11.118	10.380	9.712	9.108	8.559	8.061	7.606	7.191	6.811	6.462	6.142	5.847	5.575	5.324	5.092	4.876	4.675	4.489	4.315	4.153	4.001	3.859
16	11.652	10.838	10.106	9.447	8.851	8.313	7.824	7.379	6.974	6.604	6.265	5.954	5.668	5.405	5.162	4.938	4.730	4.536	4.357	4.189	4.033	3.887
17	12.166	11.274	10.477	9.763	9.122	8.544	8.022	7.549	7.120	6.729	6.373	6.047	5.749	5.475	5.222	4.990	4.775	4.576	4.391	4.219	4.059	3.910
18	12.659	11.690	10.828	10.059	9.372	8.756	8.201	7.702	7.250	6.840	6.467	6.128	5.818	5.534	5.273	5.033	4.812	4.608	4.419	4.243	4.080	3.928
19	13.134	12.085	11.158	10.336	9.604	8.950	8.365	7.839	7.366	6.938	6.550	6.198	5.877	5.584	5.316	5.070	4.843	4.635	4.442	4.263	4.097	3.942
20	13.590	12.462	11.470	10.594	9.818	9.129	8.514	7.963	7.469	7.025	6.623	6.259	5.929	5.628	5.353	5.101	4.870	4.657	4.460	4.279	4.110	3.954
21	14.029	12.821	11.764	10.836	10.017	9.292	8.649	8.075	7.562	7.102	6.687	6.312	5.973	5.665	5.384	5.127	4.891	4.675	4.476	4.292	4.121	3.963
22	14.451	13.163	12.042	11.061	10.201	9.442	8.772	8.176	7.645	7.170	6.743	6.359	6.011	5.696	5.410	5.149	4.909	4.690	4.488	4.302	4.130	3.970
23	14.857	13.489	12.303	11.272	10.371	9.580	8.883	8.266	7.718	7.230	6.792	6.399	6.044	5.723	5.432	5.167	4.925	4.703	4.499	4.311	4.137	3.976
24	15.247	13.799	12.550	11.469	10.529	9.707	8.985	8.348	7.784	7.283	6.835	6.434	6.073	5.746	5.451	5.182	4.937	4.713	4.507	4.318	4.143	3.981
25	15.622	14.094	12.783	11.654	10.675	9.823	9.077	8.422	7.843	7.330	6.873	6.464	6.097	5.766	5.467	5.195	4.948	4.721	4.514	4.323	4.147	3.985
26	15.983	14.375	13.003	11.826	10.810	9.929	9.161	8.488	7.896	7.372	6.906	6.491	6.118	5.783	5.480	5.206	4.956	4.728	4.520	4.328	4.151	3.988
27	16.330	14.643	13.211	11.987	10.935	10.027	9.237	8.548	7.943	7.409	6.935	6.514	6.136	5.798	5.492	5.215	4.964	4.734	4.524	4.332	4.154	3.990
28	16.663	14.898	13.406	12.137	11.051	10.116	9.307	8.602	7.984	7.441	6.961	6.534	6.152	5.810	5.502	5.223	4.970	4.739	4.528	4.335	4.157	3.992
29	16.984	15.141	13.591	12.278	11.158	10.198	9.370	8.650	8.022	7.470	6.983	6.551	6.166	5.820	5.510	5.229	4.975	4.743	4.531	4.337	4.159	3.994
30	17.292	15.372	13.765	12.409	11.258	10.274	9.427	8.694	8.055	7.496	7.003	6.566	6.177	5.829	5.517	5.235	4.979	4.746	4.534	4.339	4.160	3.995
40	19.793	17.159	15.046	13.332	11.925	10.757	9.779	8.951	8.244	7.634	7.105	6.642	6.233	5.871	5.548	5.258	4.997	4.760	4.544	4.347	4.166	3.999