National Exams December 2019

16-Civ-B11: Structural Materials

3 hours duration

## NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit a clear statement of any assumptions made with the answer paper.
2. This is an OPEN BOOK examination. One ***Text Book*** of candidate's choice is allowed.The textbook can have notations listed on the margins but no loose notes are permitted.
3. Please answer all 5 (FIVE) questions. All questions carry equal weight.
4. In case of numerical problems, the candidate needs to show all works. For non-numeric questions, clarity and organization of the answer are important.
5. Any non-communicating calculator is permitted.

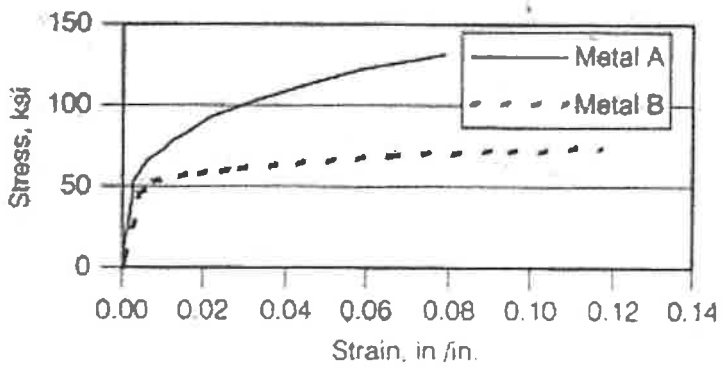
Q.1

(a) Define static and dynamic load application with examples. What do you mean by time-dependent response of materials? Explain Creep and Viscous flow with specific examples. (3+3+4 = 10 points)

(b) Figure below shows the stress-strain relationships of metals A and B during tension test until fracture. Determine the following for the two metals.

I. Proportional limit
II. Yield stress at an offset stain of 0.004
III. in/in
IV. Ultimate strength
V. Modulus of resilience
VI. Toughness
VII. Which metal is more ductile and why?

(10 points)




Q.2

(a) The following laboratory tests were performed on aggregate samples:

I. Durability test, and
II. Soundness, and
III. Sieve analysis test

List the significance and application of each of these tests. (6 points)

(b) Perform the sieve analysis of the following aggregate and determine the fineness modulus (FM) for the aggregate sample. Plot cumulative percent passing versus sieve size graph on a semi-log paper and comment on the gradation based on the shape of graph. (14 points)

| Sieve Size, mm | Amount Retained, gm |
|---|---|
| 25 | 0 |
| 9.5 | 45.2 |
| 4.75 | 289.6 |
| 2.00 | 145.7 |
| 0.425 | 128.8 |
| 0.075 | 64.4 |
| Pan | 4.3 |

Q.3

(a) Define curing of Portland cement concrete and its importance. What do we mean by alternatives to conventional concrete? Identify any four alternative concretes with their application and advantages. (2+2+6 =10 points)

(b) In a ready-mix plant, cylindrical samples are prepared and tested periodically to detect any mix design problems and to ensure that the compressive strength is higher than the lower specification limit. The minimum target value for compressive strength was set at 4250 *psi*. The following compressive data were collected.

| Sample No. | Compressive Strength, psi | Sample No. | Compressive Strength, psi |
|---|---|---|---|
| 1 | 4875 | 14 | 5675 |
| 2 | 4800 | 15 | 4315 |
| 3 | 5250 | 16 | 5175 |
| 4 | 4125 | 17 | 4770 |
| 5 | 5110 | 18 | 4874 |
| 6 | 4316 | 19 | 5134 |
| 7 | 4940 | 20 | 3692 |
| 8 | 4950 | 21 | 4510 |
| 9 | 4730 | 22 | 3875 |
| 10 | 4205 | 23 | 4100 |
| 11 | 4570 | 24 | 3780 |
| 12 | 4324 | 25 | 3925 |
| 13 | 4235 | | |

Calculate the mean, standard deviation, confidence interval (CI), and the coefficient of variation (COV) of the test data. Is the plant production meeting the specification requirement? If not, comment on possible reasons. Comment on the quality of data. (10 points)

Q.4

(a) For asphalt concrete, define (9 points)

i. Air voids (VTM)
ii. Voids in the mineral aggregate (VMA)
iii. Voids filled with asphalt (VFA)

(b) The Marshall method was used to design an asphalt concrete mix. An AC-30 asphalt cement with a specific gravity ($G_b$) of 1.031 was used. The mix contains a 9.5 mm nominal maximum particle size aggregate with a bulk specific gravity ($G_{sb}$) of 2.696. The theoretical maximum specific gravity of the mix ($G_{mm}$) at asphalt content of 5.0% is 2.470. Trial mixes were made with average results as shown in the following table.

| Asphalt Content $P_b$ (% by Weight of Mix) | Bulk Specific Gravity ($G_{mb}$) | Corrected Stability | Flow (0.25 mm) |
|---|---|---|---|
| 4.0 | 2.360 | 6.3 | 9 |
| 4.5 | 2.378 | 6.7 | 10 |
| 5.0 | 2.395 | 5.4 | 12 |
| 5.5 | 2.405 | 5.1 | 15 |
| 6.0 | 2.415 | 4.7 | 22 |

Determine the design asphalt content using the Asphalt Institute design criteria for medium traffic. Use design air void content of 4% to find minimum VMA. (11 points)

Q.5

(a) A wood specimen was prepared with dimensions of 1.5 inch x 1.5 inch x 5 inch and grains parallel to the length. The specimen was subjected to compression parallel to the grains to failure. The load-deformation results are given below.

Load-Deformation Table

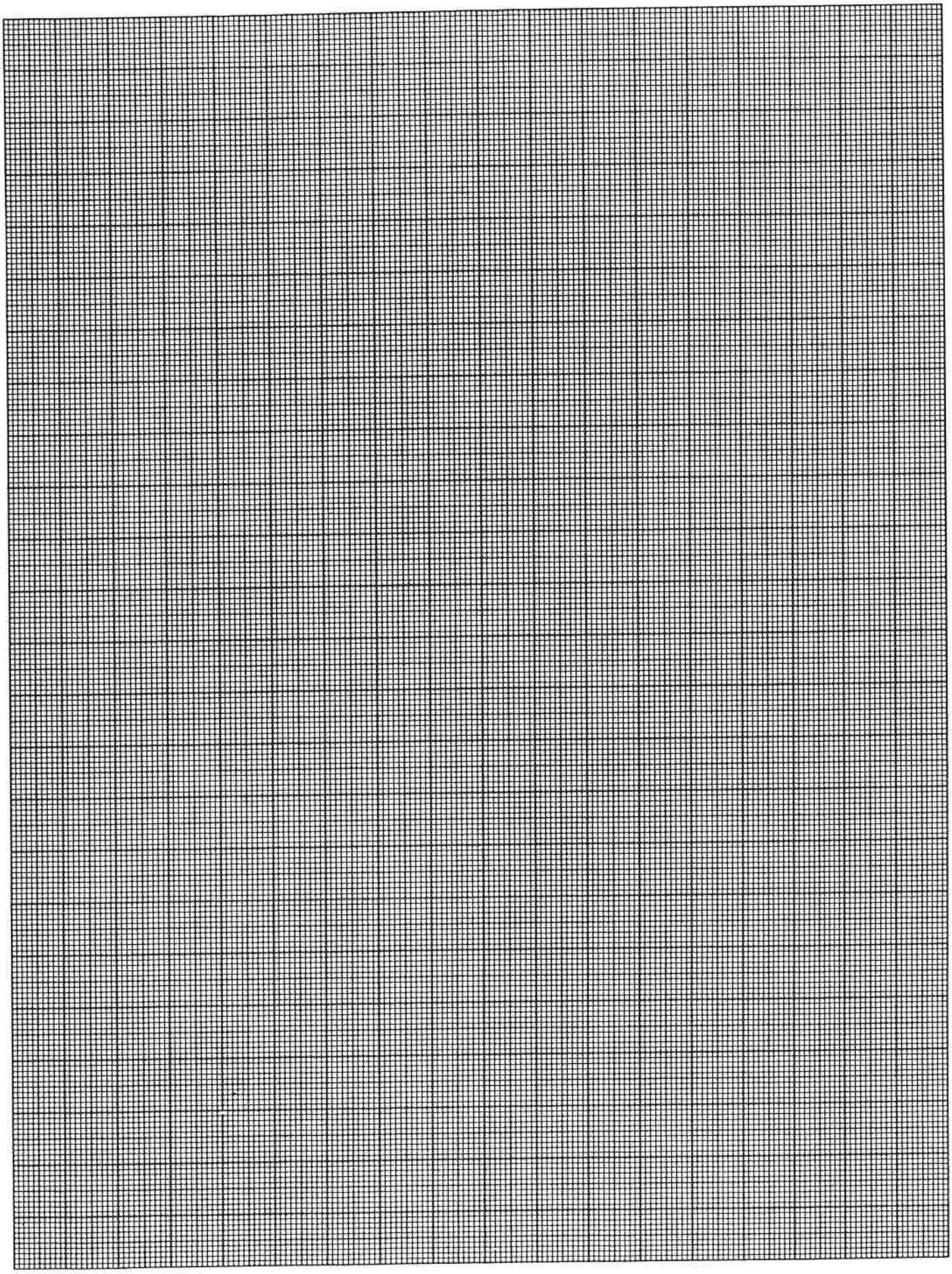
| Load, lb | Displacement, inch |
|---|---|
| 0 | 0 |
| 20 | 0.015 |
| 35 | 0.065 |
| 85 | 0.160 |
| 475 | 0.175 |
| 1650 | 0.205 |
| 2575 | 0.228 |
| 3825 | 0.255 |
| 4575 | 0.255 |
| 5325 | 0.315 |
| 5125 | 0.355 |
| 4575 | 0.370 |
| 4350 | 0.395 |

Plot the stress-stain relationship on a normal graph paper and calculate the modulus of elasticity. What is the failure stress? (12 points)

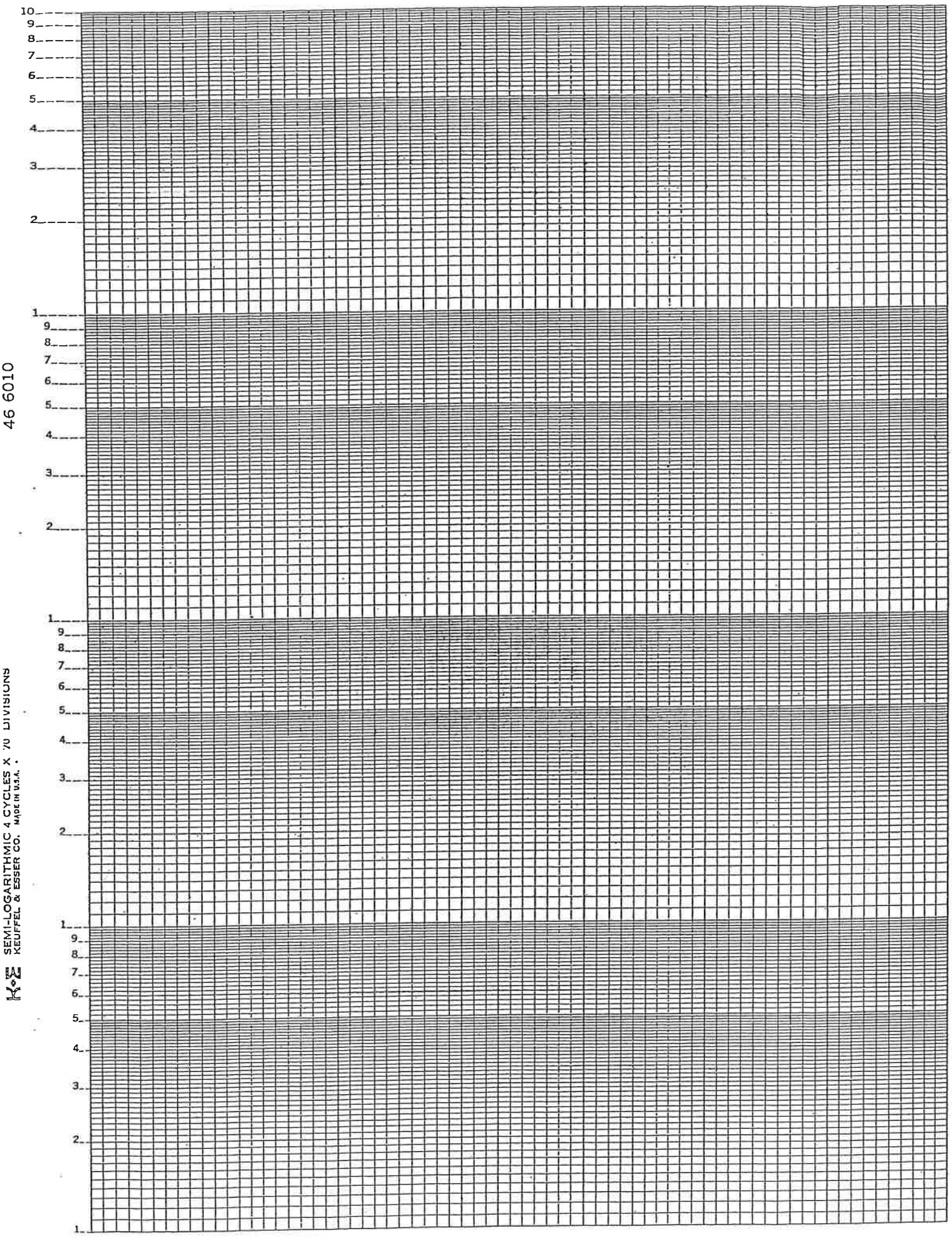
(b) The following laboratory tests are performed on steel specimens:

i. Tension Test
ii. Torsion Test
iii. Charpy V notch test
iv. Bend Test

What are the significance and use of these tests? (8 points)



10 MM/CM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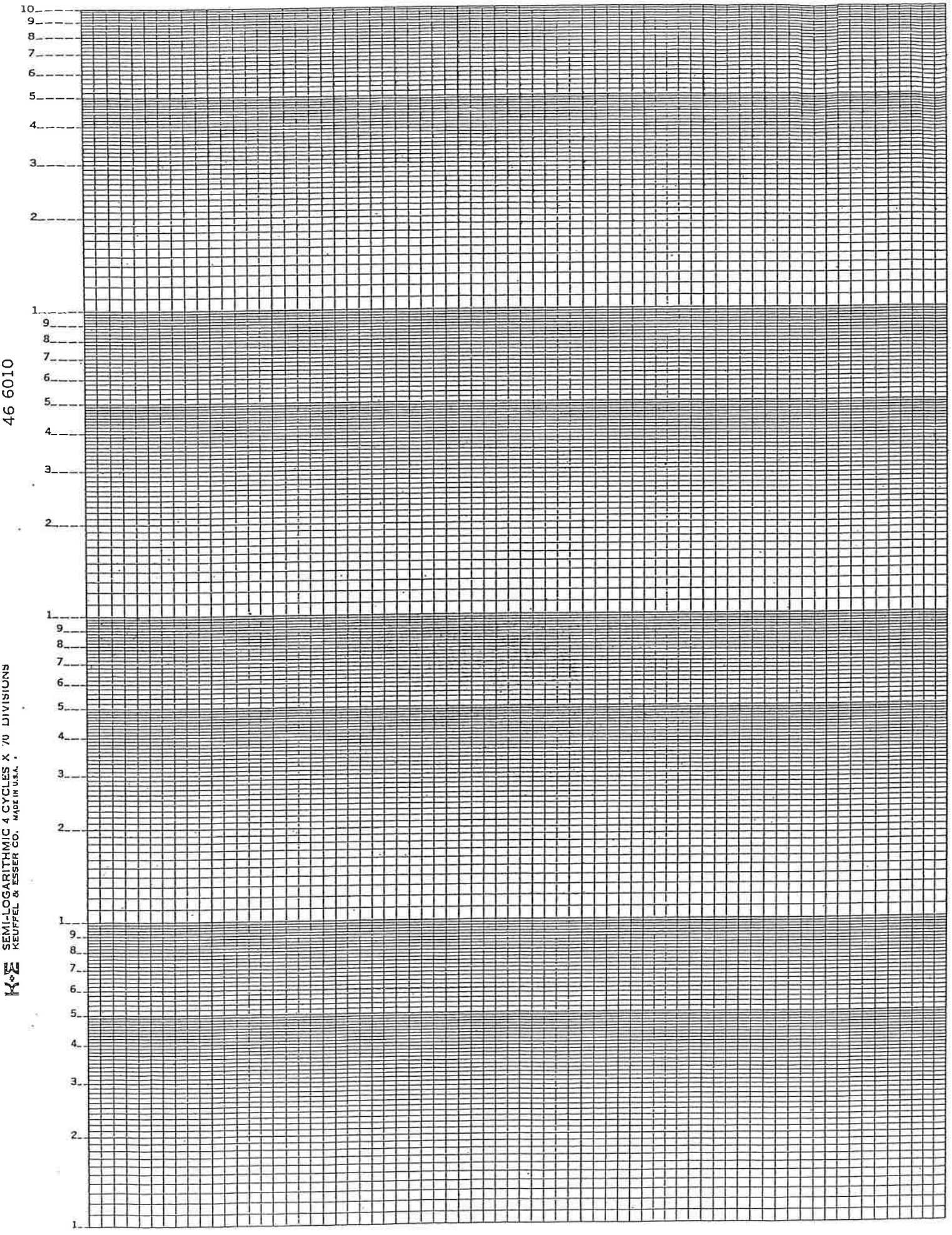
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