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A SIMULATION APPROACH TO OFFICE AND CLASSROOM
ILLUMINATION

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MASTER OF SCIENCE

by

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August, 1978

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ABSTRACT

"A SIMULATION APPROACH TO OFFICE AND CLASSROOM
ILLUMINATION"

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An experimental research has been conducted to determine the adequate illumination level for office interiors. A simulation room has been established for the purpose. Three different factors were considered in the research, namely, intensity of illumination, task detail size and contrast values. For the specific simulation conditions, it was found that an illumination level of 300 lux for office interiors produces better performances.

Key Words: Illumination level, task detail size, contrast values, simulation, office work.

Ö Z E T

"OFİS VE SINIF AYDINLATILMASI PROBLEMİNDE
BENZEŞİM YAKLAŞIMI"

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Ofis aydınlatması için gerekli ışık düzeyini saptamak üzere deneysel bir araştırma yürütülmüştür. Bu amaçla bir benzeşim odası oluşturulmuştur. Araştırmada faktör olarak ışık miktarı, iş detay büyüklüğü ve kontrast değerleri ele alınmıştır. Belirli benzeşim koşullarında, 300 lux değerinde bir ofis içi aydınlatmasının işlerin yürütülmesinde yüksek verim sağlayacağı belirlenmiştir.

Anahtar Kelimeler: Aydınlatma düzeyi, iş detay büyüklüğü, kontrast değeri, benzeşim, ofis işi.

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CHAPTER I

INTRODUCTION

In general , the effect of illumination level on visual performance depends mostly on the importance of the visual discrimination of fine details of work and upon the difficulty of these discriminations in relation to size, contrast, movement, etc. (22).

Visual perception makes up 85-90 % of the total perceptual activities of the human sensory system (28). In ergonomics, vision and visual perception has been dealt with in most of the research work leading to betterment of task performance.

The level of illumination at a work station is one of the important factors which affect visual perception besides the task size, contrast, shadows, glare, environmental reflectances, etc. Thus, if some of the above factors can be controlled and maintained at constant levels, a study of the effects of the levels of illumination may be undertaken. In most of the industrialized countries extensive studies have been done on the standards of illumination for certain types of visual tasks. Different standards for similar tasks have been recommended, and great differences between those recommendations create a necessity for research in developing

countries. Before the adaptation of any level of illumination as a standard, an extensive research must be conducted and suitable levels of illumination for different tasks and work stations should be established scientifically.

In our country there is an urgent need for such standardization in order to increase the production rate and to eliminate adverse effects of poor illumination. It appears that we have to do extensive research in this field, and throughout our efforts we have to consider the problems of energy shortages and economy of illumination in this country.

Hypothetically, the standards of office illumination vary to a great extent in our country and standards of different origins are used which sometimes result in waste of electrical energy and in some others inadequate illumination.

CHAPTER II

TECHNICAL ASPECTS OF OFFICE ILLUMINATION

In any workplace, where the task necessitates a considerable amount of visual discrimination, illumination as well as other relevant factors must be studied carefully. If the discriminatory requirements are not considered, the work done will be poor both in quality and quantity. In general, technological developments leading to automation at work decrease the mechanical work to be done by man but increase the stress over the eyes. However, an occupational health or productivity approach must always consider the visual performance of the operator if we expect a higher output after some technological remodelling.

In highly industrialized countries, despite the presence of a wealth of significant and applied research in the domain of office illumination one can easily recognize great difference of recommended level for office illumination. In Table 1 values established as standards for office illumination by different countries are given.

Table 1. Standard Illumination Level for Office Interiors

<u>Country</u>	<u>Year</u>	<u>Illumination (lux)</u>
Australia	1965	300-500
Hungary	1965	300-450
DDR	1966	400-1000
Netherlands	1967	500-1000
Czechoslovakia	1967	300-500
Poland	1969	300-500
Japan	1969	300-450
USSR	1971	300-500
France	1971	300-1000
BRD	1972	500-1500
Great Britain	1973	500-750
USA	1973	750-3000

Recommendations of Illuminating Engineering Society
are between 30 lux and 200 lux for the office interiors
(1966)

Providing a high level of illumination at a place is not always providing for adequate illumination. A high level of illumination may increase the problems of glare and result in fatigue unnecessarily. We must also consider the maintenance of brightness contrast for productive work. The hazards of modern sources of light must also be taken into account. Fluorescent lamps and their flickering effects, and the hazards of high power mercury lamps should also be emphasized and studied.

Brilliance of the background for a visual task is one of the factors which can be manipulated. Brilliance can be defined as the product of the level of illumination and the reflectance coefficient of the surface.

Research for illumination only is not sufficient for developing adequate visual environment. It is also necessary to arrange the light sources in such a way that they will not cause discomfort. A glaring object within the field of vision decreases discriminatory capacity of the eyes. Disability glare causes a complete malfunctioning of the eye. Discomfort glare, as the name implies, is the glare within the field of vision not necessarily causing discomfort directly but irritating the worker and resulting in visual stress within time.

For the establishment of the most adequate visual environment, the illumination of the environment must be close

to the illumination of the background of the task (10). Higher levels of illumination of the environment will cause discomfort and unsatisfactory illumination will decrease the visibility of the objects. As a common measurement, the illumination of the environment of the work place must not be less than the square root of the luminance value of the work place in lamberts (10).

Shadows may also result in discomfort according to their degrees and directions. Deployed illumination by as many light sources as necessary will avoid shadows. Illumination from a single source will always form dark shadows. On the other hand, too many light sources with varying intensities will result in multi-shadows and may cause discomfort as well thus, the arrangement of the light sources must be made carefully. For office work, diffuse light, which produces no shadow results in higher performances.

Contrast between the color of the object and the color of the background is as important as the brightness contrast. However, for office type work, color may not be an important factor. All can be said about color is that spectral composition of the light from the source must conform to the color the object for a good color effect.

Discussions on light bulb (filament) illumination versus fluorescent illumination did not reach a conclusion yet. Both

of these sources have their own advantages and disadvantages.

Light bulb illumination is used extensively. It is cheap but the light obtained is yellow-green. The colors at the blue side of the spectrum seem pale under these light bulbs. But, on the other hand, the light does not flicker even when local electrical power shows variations. When shadows are removed from the work place by proper design, filament lamp illumination is accepted to be less tiring (10).

In fluorescent illumination, variations in city voltage results in flickering of the light. This flickering is felt at the periphery of the field of vision. This causes indirect fatigue of the eye and cumulative effect of this fatigue may cause damage to the visual organ in the long run. However, the flickering can be reduced by assembling the tubes in groups of two or three and use a condenser to get rid of the dark phases of the light source (10). The presence of two maximum spectral points of the light of fluorescent tubes results in neural disturbances which is manifest in the fatigue of visual organ (Dichroique effect). The radiation of ultra-violet rays from the tubes is far above acceptable level (10). Too long exposure may result in formation of conjunctivitis of the eye. In order to avoid this harmful effect, the tubes must be placed at least eighty centimeters far from the eyes, and for eliminating

shadows, diffusing plates must be placed over the tubes. All these characteristics do not limit the use of fluorescent tubes in illumination.

One other approach which has been discussed is the economy and superiority of the natural light for illumination over artificial lighting. However, the intensity of the daylight varies to a great extent during the day and is highly dependent on the seasonal changes. Also, its quality or color and proportions of diffuse and directional light change in time. Artificial lighting produces steady illumination, however, it may also result in stagnancy and monotony. Stagnancy may evoke the feeling of boredom where as moderate rate of change may give a pleasurable feeling of freshness. When natural light is omitted by design, artificial light may be psychologically disturbing due to its stillness even if its quality and quantity is adequate. On the other hand, artificial light can be controlled more extensively both in quality and quantity.

In a study for adequate illumination the effects of visual functions should also be considered. For example, visual acuity and other visual functions such as phorias must be studied extensively if efficiency of the lighting system is to be generalized. Visual acuity is the ability of the eye to distinguish fine details. This is largely controlled by

accommodation of the eyes. Accommodation is the adjustment of the lens of the eye to bring about proper focusing of the light rays on the retina. Inadequate accommodation results in near-sightedness or far-sightedness. Normalization of visual performance can be obtained by correcting the defects in accommodation.



CHAPTER III

THE WORK OF OTHERS

Illumination and its effect on performance for various tasks have been studied extensively in the past and standard levels of illumination are suggested. The trend is however, an increasing level of illumination especially in developed countries. For a sound research, it is important to know what has been done in this field up to now. A library research was conducted by the researcher and all of the available papers were studied for their relevant aspects. Findings of this survey are presented in summary.

Weston (1962) developed a methodology for the determination of required illumination levels for various visual tasks. His method involves the utilization of a nomogram (Appendix A) for the determinations. The nomogram is prepared in consideration of some measurable variables such as :

- i) The actual size of the critical detail to be discriminated,
- ii) The distance from the worker's eyes at which the task will usually be situated,
- iii) The reflection factor of the detail or its immediate surrounding, whichever is higher.

Weston also stated "When an occupation involved critical vision not continuously but rather occasionally, the overall performance of the work might not be significantly affected if the illumination provided for it is made somewhat lower than the standard advisable when similarly critical vision is required continuously" (28).

For the past forty years, research in the field of illumination dealt with some physiological responses of the body that would serve as an index of the effort, or physiological cost of vision under poor conditions as contrasted with good conditions. Nervo-muscular tension, blink rate, heart rate, etc., have been studied by H.K. Hartline (1938), L.A. Riggs (1953) and others, and widely accepted results have been obtained (22). During the last decade, several of the Illuminating Engineering Research Institute (IERI) researchers tried to study the correlation between the effort for perception under different conditions and the movements of the muscles of the eye. Within this frame work Dr. Hebbard (1969) studied intricate eye movements during visual perception. These micro eye movements are found to be autonomous and they consisted of turning the eye slightly to allow fresh reserve of the retina to come into play so as to continue the clear vision. Dr. Hebbard has found that at a very low illumination level, the eye has to make wider sweeps to substitute more and more

cells to pick up the weak stimulus. At a higher level of illumination the sweeps are much smaller, and therefore, fewer cells are in visual perception (16).

In short, Dr. Hebbard found that the eyes have to do much more work to see under unfavorable illumination conditions. The author defines the unfavorable conditions as low levels of illumination or presence of discomfort glare or both. Minimum visual effort is required when there is a sufficiently high level of illumination over the task and the background as well as the immediate surroundings. This illumination should be in harmony with the brightness requirement of the task.

Dr. Hebbard varied visibility by varying the contrast of a fixation task at a given luminance in the first set of the experiments and varied visibility by varying the luminance for a fixed contrast in the second set. In both sets, he measured the effect of the change in the visual task upon the variability of ocular fixation and accuracy of task performance. As a result, the researcher found that variability in ocular fixation at lower illumination level was more than at higher illumination level (16). In another word, the eye muscles must do much more work for the perception of stimulus at low levels of illumination than at higher levels.

McNelis and Guth (1969) developed experiments for obtaining information on the contrast-luminance relationship for several types of test objects such as disks (which were also used by Blackwell and Smith for deriving Illuminating Engineering Society (IES) Performance Curve (3)), lines, printed letters, handwritten letters, dot patterns, and grating which all varied in size and degree of complexity (Appendix B). In their experiments, the test objects appeared as luminous targets in the center of an extensively uniform field. Target luminance was varied which corresponded to contrast changes. The exposure time of the targets was fixed. The results of the experiments showed that the functional relationship between contrast and luminance is dependent upon the type of test object involved (23).

Conner and Ganoung (1935) studied the resolution of breaks in Landolt rings varying in size and contrast at different illumination level. They used long exposure times in their experiments (5). Blackwell and Blackwell (1968) stated that the visual aspects of the performance of real tasks improves continuously as light intensity increases. They argued that, although this was the case, there existed no sufficient knowledge about the cause of this important effect of illumination. They thought that their study on the effect of illumination upon the performance of different visual tasks

will reveal knowledge about the causal variables at work (such as contrast, task size, etc.) and they did obtain information on effects of contrast (5). In their experiments they distinguished tasks involving contrast discrimination and the ones involving visual acuity. Tasks of large size but small contrast were named as pure contrast discrimination tasks. The ones of large contrast were defined as pure visual acuity tasks. They defined visual acuity as an inversely proportional value of the minimum size required for optical resolution. They used solid disks of varying sizes and contrast at different illumination levels in their experiments. As in experiments of Conner and Ganoung, they utilized long exposure times. In both of these studies, it was shown that luminance had similar effects on contrast sensitivity and visual acuity performances (5).

In one of his studies, Blackwell (1959) studied the levels of illumination required for the performance of different visual tasks and proposed a method for the determination. The method Blackwell established utilized a performance curve, which was also called IES Performance Curve. He also devised an instrumental method for visual task evaluation.

Towards 1968, Blackwell attempted a different method for the determination of the illumination levels. The latter study involved consideration of additional factors influencing task difficulty and thus affecting levels of illumination.

Some of these factors were:

- i) The angle at which the task is viewed,
- ii) The informational requirement of the task,
- iii) The reduction in task contrast due to the effects of obscuring reflections,
- iv) The reduction on image contrast due to the disability glare,
- v) The reduction in visual performance capability due to the transitional adaptational effect (3).

In this revised method, the task difficulty was defined in terms of psychophysical and physical quantities. Quantifications were made on Task Information Index (TII), Factor for Viewing Angle (FVA), Visual Contrast Rendition Factor (CRF), Disability Glare Factor (DGF); and Transitional Adaptation Factor (TAF) (3).

In a later study, Blackwell (1969) measured Contrast Rendition Factor for four pencil targets, at each of five viewing angles and under fifty-three lighting levels. The results of these experiments showed that in the establishment of illumination levels required for a given task it was necessary to measure the reflection factor, especially when different lighting installations are used (4).

By using his own Visual Task Evaluator (VTE) technique, Blackwell studied the visual difficulty of the fixation tasks

that Dr. Hebbard used to evaluate the accuracy of ocular fixation (16). He considered the results of this study as a support for the appropriateness of the levels of visual performance built into the current IES Lighting Recommendations. This visual performance criterion is expressed in terms of an index of the visibility for each task. Easy tasks require less illumination to reach the standard level of visibility while difficult tasks require much more illumination for same level of visibility. In his research, the author utilized the fact and concluded that "Providing high level of illumination for a task leads to higher task visibility which, in turn results in a rapid and accurate performance of the task" (2).

Boynton, Rinalducci and Sternheim (1969) conducted a similar study. The purpose of the study was to measure the extent of loss in visibility due to sudden changes in the level of illumination, either to a higher or to a lower level. They worked on dark adaptation and light adaptation capabilities of the eye. They found that, up to the levels of 400 fL luminance the visibility loss depended mostly upon the ratio of the change and was relatively independent of the absolute levels. Also they arrived at the fact that it makes little difference whether the change is up to higher or down to lower levels of illumination (8).

Fry and Cobb (1963) conducted an experiment on visual acuity and illumination levels and demonstrated that determination of illumination level must be done more critically for finer works than for coarser works in order to increase productivity and efficiency of the worker at the work bench (1).

It has been shown that higher levels of illumination lead to the advantages like improved visual acuity (Hecht, 1928), shorter visual reaction times (Pieron, 1939), and reduced contrast thresholds (Blackwell, 1946). However, this paper analyzes a visual task which critically require use of the peripheral vision as well as foveal vision. Peripheral vision is indistinct, that is fine detail cannot be resolved within the area of peripheral vision. It is a generally accepted fact that there exists a tendency to turn the eyes toward a bright object in the visual field due to fixational reflex of the visual organ, but, on the other hand, attention is usually attracted toward an object not because it is bright but rather because it is meaningful. Thus, basic reflex is controlled or rather suppressed by the distracting projected information from peripheral stimulus. By making use of these facts, Boynton and Boss (1971) designed an experiment and utilized a visual search task. This task involved detection of a square spot among an array of dark circular spots. Random arrays of spots were shown repeatedly where a square spot

took place only in some occasions. In the experiment, the contrast between the square spot and background was varied by varying background luminance and thus a graded level of task difficulty was provided. In a second series of experiments, the size of the stimulus was also varied by varying the size of the spots. The results of both sets of the experiments demonstrated that :

- i) Effect of reducing either luminance or contrast impairs visual performance,
- ii) At 100% contrast, luminance has a very small effect upon performance in the range 28.5-109 lux. Further lowering of luminance has a significant and progressively-accelerating negative effect upon performance.
- iii) There is a little effect of contrast variation in the range from 40 to 100 percent at an illumination level of 109 lux. A slight decrement occurs at 20% and a very significant performance drop occurs between 10% and 5 % contrast (7).

Within the explored limits, visual performance has been found to be maximum at the highest contrast and luminance used. Whether or not small downward changes in either or both of these variables will always result in decline in performance. This effect was found to be highly dependent upon the initial

task difficulty. Finally, it was concluded that "the most significant losses in visual performance occurred when luminance was below 23 fL level and/or contrast was below 10:"(7).

Chorlton and Davidson (1970) concluded that empirical measurements of losses in contrast under real lighting situations can be very large (25).

The Recommendations for Quality and Quantity of Illumination (RQI) developed a new method for evaluating lighting systems in terms of both the actual illumination provided and the effectiveness of the illumination in relation to the visibility that will result.

In this evaluation method, Task Illumination, Equivalent Sphere Illumination and Lighting Effectiveness Factor figures are used. As the viewing angle 25° with the vertical is taken for the task. This angle is found to be the angle of greatest frequency for viewing office and school tasks according to the society. For measurements prior to the evaluation, instruments such as luminance meter, illumination meter, non polarizing luminance meter, visual task photometer were used (25).

Eastman (1971) had conducted a comparative study and found that high visibility tasks are less affected by changes in luminance levels than low visibility tasks (11).

In his paper, required luminance is defined as "A term to designate the background luminance a task must have for a standard observer to achieve the visual performance indicated by the Illuminating Engineering Society (IES) performance curve " (18).

Boyce (1973) found a strong relationship between the age of workers and the performance at different illumination levels in his studies (6). However, Lowson (1973) stated that the idea that older workers cannot work efficiently unless supplied with more light than normal is actually a fallacy(21), while World Health Organization (WHO) introduced the idea that "For equal visual effectiveness, the amount of illumination required for an individual doubles for every thirteen years" (26).

Faulkner and Murphy (1973) stated that there exists two basic approaches for improving task visibility one is to change the task and the other is to change the illumination provided for the task. Task can be changed by magnification by using different materials or finishes for changing the specularity of the reflected light or introducing additional chromatic contrast. However, because of the relative ease with which the quantity of light can be increased, there has been a tendency to think of increases in quantity as being

the easiest means of improving the effectiveness of an illumination system. The authors introduced the idea that, in actual practice, the improvements in task visibility that can be achieved by using special purpose lighting are usually greater than the improvements obtained through increasing general illumination level. They produced a list of seventeen special lighting systems for producing different visual effects which will be most suitable for certain visual tasks (12).

The lighting systems are :

- 1) Color
- 2) Transillumination
- 3) Crossed polarization
- 4) Polarized light
- 5) Shadow-graphing
- 6) Spotlighting
- 7) Brightness patterns
- 8) Diffuse reflection
- 9) Edge lighting
- 10) Dark field illumination
- 11) Convergent light
- 12) Stroboscopic lighting
- 13) Moving light images
- 14) Surface grazing or shadowing

- 15) Block light
- 16) Moire patterns
- 17) "Combination" lights (12).

Fischer (1973), in his work, compared interior lighting recommendations accepted by some European countries. This comparative study shows the high variability among the levels recommended for the same task by different countries (14).

Plant and Archer (1973) developed a computer programme for predicting luminance and illuminance levels in any rectilinear environment with considerable accuracy, according to given sources of light, both natural and artificial. The program simulates inter-reflection by dividing each surface into numerous cells and considers the exchange of light between all of the pairs of cells (24).

Goodbar (1974) developed a simplified method for predicting contrast. This method was based on two overlaying (graphical) charts for computing contrast due to light coming directly from the luminaires and two other overlaying charts for computing contrast due to light reflected by the room surfaces. The method is also useful for predicting illumination on the task, its background luminance, and the luminance difference between the detail and its background (15).

Yapaneshikov, Perova and Undasymov (1974) conducted a study for the determination of optimum illumination level for office interiors. They set up a test room for their experiment. The visual task selected was a correction work. The level of illumination at the test room was varied between 100 and 3000 lux values. The correction work had a contrast of 50% with the background.

The results of the experiment demonstrated that the productivity of worker increases smoothly with the increasing level of luminosity, although this increase is rather slight. On the other hand, high levels of brightness of the working surface and of the background stresses the observer and causes considerable visual fatigue during the performance of the visual task.

In a second series of experiments, the subjects were given three different tasks to perform consecutively reading of typographical texts, performing calculations on slide-rule, drawing simple sketches. The illumination level was varied between 100 and 3000 lux. After performing each proposed task for one minute, the observer was asked to evaluate conditions of illumination according to a five mark scale by stating one of "very good light, good light, just enough light, insufficient light, dark". These subjective evaluations of the observers were considered as an opinion survey and used to determine optimum illumination levels for different tasks(29).

CHAPTER IV

METHODS AND INSTRUMENTATION

The present study is aimed at the determination of changes in visual performance as a function of three factors, namely, illumination level, brightness contrast, and task detail size. The experimental design of the research involved five levels of illumination, three levels of brightness contrast, and three levels of task detail size. The design of the experiment was a 5×3^2 factorial design. All three factors were quantitative, that is each factor can be represented by points on a specific scale. However, Visual Task Evaluator (VTE) or Eastman Contrast Threshold Visibility Meter (CTM) are needed for the measurement of the brightness contrast. Due to difficulties in obtaining these two instruments, brightness contrast was not measured and expressed in quantitative terms. However, the measurement of incident light and reflected light was possible and a comparative value for reflectance rate was computed from the above measurements (Appendix C).

A. Test Materials

The visual tasks selected for the experimental work included a text of two-pages in Latin. In the selection of Latin as the language of the text, elimination of the familiarity effects to the text was aimed, thus, only recognized

letters were marked by the subjects as requested (Appendix J).

In the experiment, the subjects were asked to cross-out the letters "a" and circle the letters "e" in the text. They were also told that time was a factor to be considered and they had to do the correction work as quickly as possible. The reason for choosing the letters "a" and "e" is that it is rather hard to discriminate one from the other, especially under poor visual conditions. Similarly, Conner and Ganoung (1935) had used Landolt rings (5) and Blackwell used solid disks and pencil targets (4) in their related studies.

The performance of the subjects were then determined as the ratio of correctly marked letters on both pages to the total time used for the test.

Textbooks and the majority of reading materials used in classes are either black-prints on first quality paper, black-prints on second quality paper or stencil-prints on second quality paper. The test pages used in the experiment were printed similarly in three different qualities and they represented three different levels of brightness contrast. Although these brightness contrast values can not be given in numerical values, the reflectance rates of the test material under different illumination levels are determined (Appendix C).

The letter size of most reading materials are found to be about 11-points for the main text, 8-points for the exercises and 6-points for subscripts. For that reason, the Latin pages have been prepared in nine different combinations of contrast and size of letters. The contrasts were obtained by different printing and quality of the paper.

Each combination of contrast and size has been tested under five levels of illumination between 50 lux and 1050 lux. Illumination levels within this range were preferred for they are in line with the recommendations of most of the countries, given in Table 1, except Japan, German Federal Republic and USA. The intervals between the illumination levels and the letter size were chosen equal, in order to be able to conduct response curve analysis on the outcomes of the experiment.

B. The Simulation Room

For conducting the experiment, a simulation room was established. For this purpose, a small room of dimensions 2.00x2.00x3.15 meter was used. The room was sealed against daylight by curtains made of two layers of heavy clothes. Inner layer was made of white material in order to reflect the lights and the outer layer was made of black material in order to prevent the penetration of the daylight into the room. All along the experiments, artificial lighting was used. For the

purpose, eighteen 100-Watt and two 300-Watt, reflector type, sodium-vapor lamps were placed in the room as luminaires (Figure 1,2). The lamps were mounted on wooden panels constructed along the walls, next to the ceiling in such a way that light was directed over the white-colored ceiling surface. Through such design, diffuse light was provided on the task and glare effects were minimized. The illumination level inside the room was controlled by using a variable transformer (VARIAC) for controlling the voltage applied to the luminaires and thus, monitoring the level of illumination (Pictures 1-4).

Incident light over the task was measured by a digital luxmeter (Gamma Scientific Incorporated Model 820 A, Digital Photometer). As shown on the Figures 1 and 2 the photosensitive detector head of the luxmeter was placed near the task and the digital read-out unit of the instrument on the observation desk outside the test room.

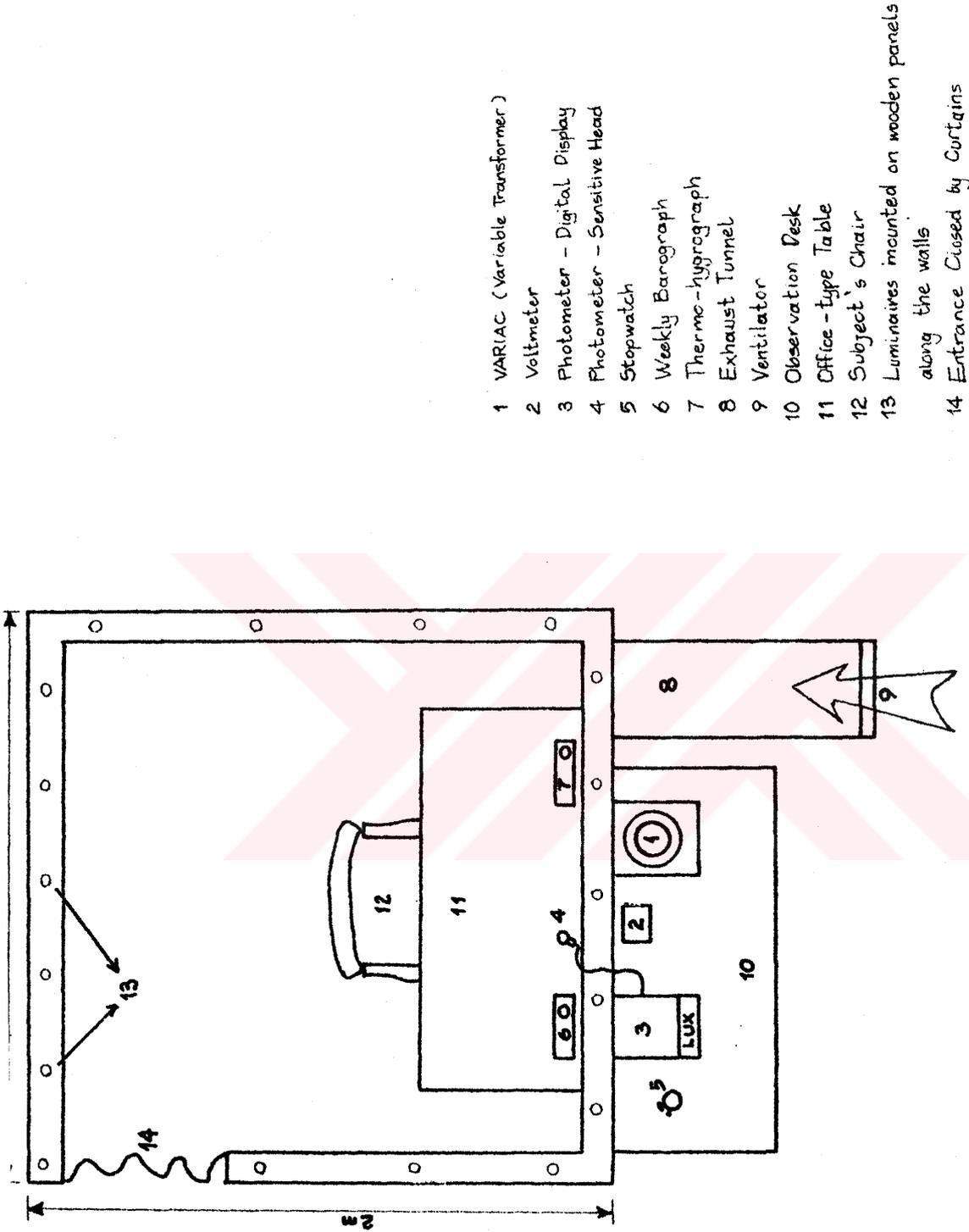
Input voltage to VARIAC and the photometer was measured by a "overload protected volt-ohm-miliammeter continuously. A thermohygrograph and a barograph was placed inside the simulation room in order to record the atmospheric conditions (temperature, barometric pressure and P_{H_2O}) inside the room through-out the experiments.

The test room was ventilated to remove the excess heat produced by the luminaires and to supply fresh air inside for

attaining comfortable working conditions in the room.

The walls of the test room have been painted white. Part of an office layout was established in the simulation room. The table and the chair was placed in a way such that the subjects faced the wall during the tests.

Termo-hygrograph and barograph readings were recorded during the experiments. The temperature level was kept within the range of 22-28°C . Mean while, during the eight days of the experimentation, the hygrograph records showed that humidity was about 45 % . Barograph records showed that barometric pressure was 986 mm Hg on the average during the experiments.



- 1 VARIAC (Variable Transformer)
- 2 Voltmeter
- 3 Photometer - Digital Display
- 4 Photometer - Sensitive Head
- 5 Stop watch
- 6 Weekly Barograph
- 7 Thermo-hygrograph
- 8 Exhaust Tunnel
- 9 Ventilator
- 10 Observation Desk
- 11 Office-type Table
- 12 Subject's Chair
- 13 Luminaires mounted on wooden panels along the walls
- 14 Entrance Closed by Curtains

FIGURE - 1

SCHEMATIC LAYOUT OF THE TEST ROOM & THE OBSERVATION DESK (TOP VIEW)

- 1 Photometer - Digital Display
- 2 VARIAC (Variable Transformer)
- 3 Photometer - Sensitive Head
- 4 Subject
- 5 Luminaires
- 6 Curtains

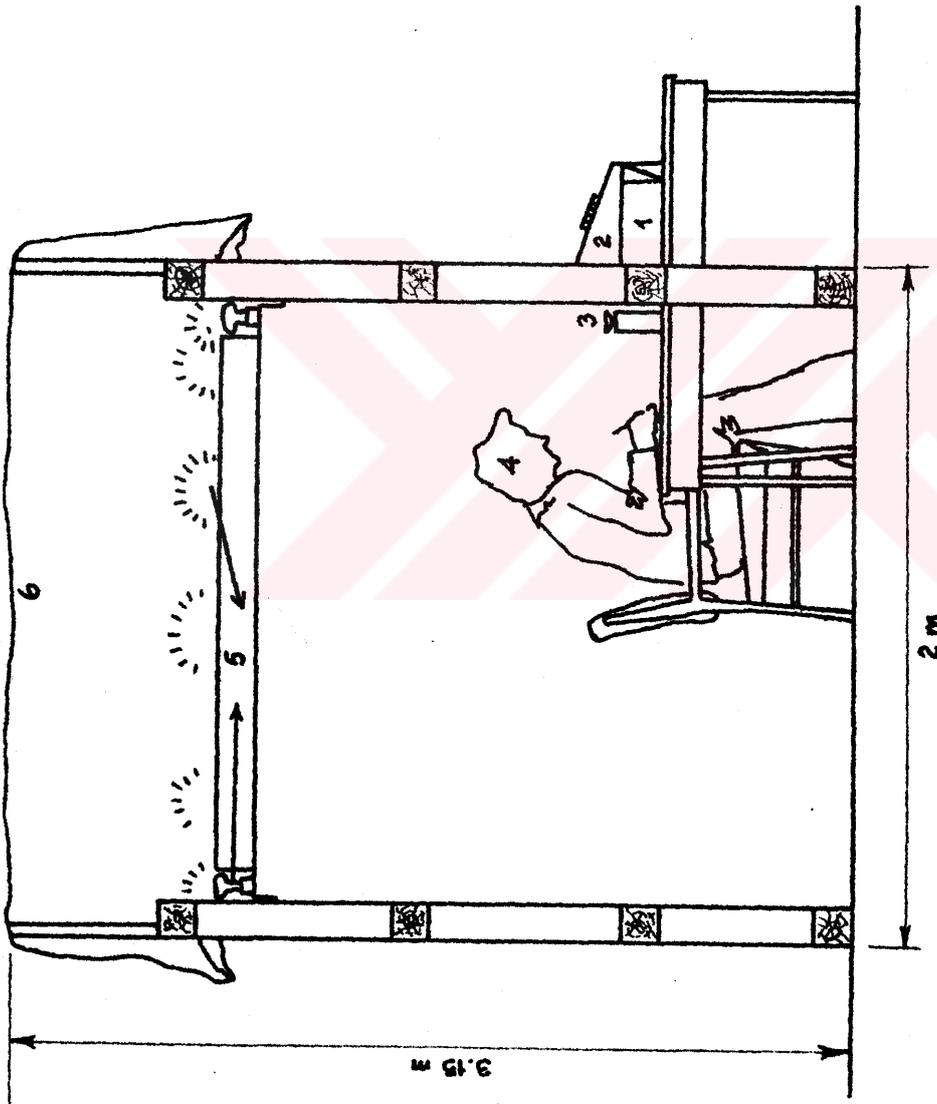
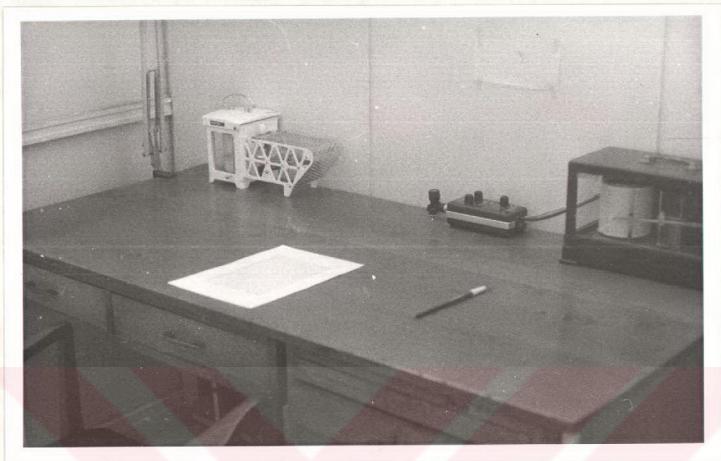
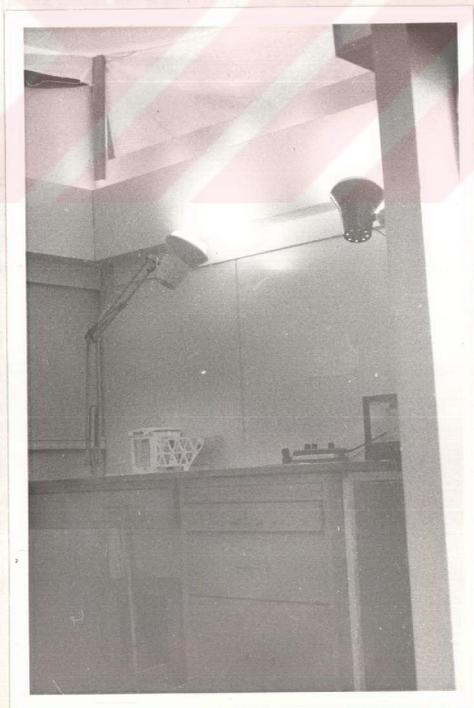


FIGURE - 2

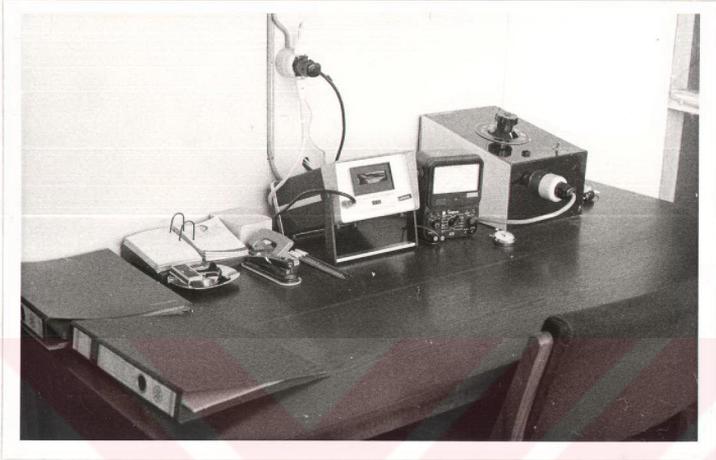
SCHEMATIC DIAGRAM OF THE TEST ROOM &
THE OBSERVATION DESK (SIDE VIEW)



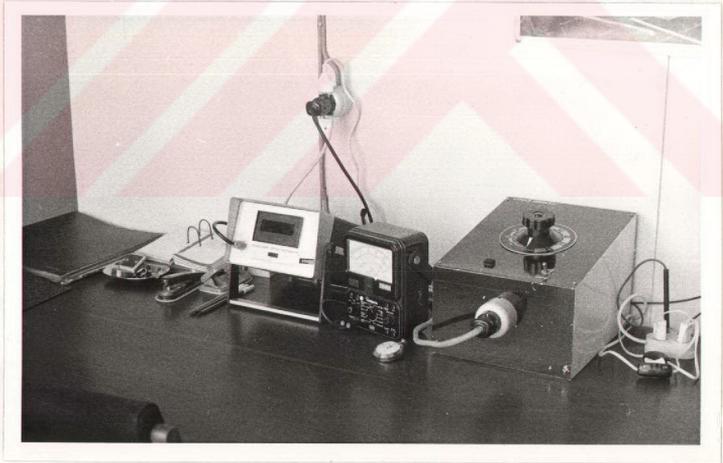
Picture 1. The Simulation Room



Picture 2. The Simulation
Room



Picture 3. The Observation Desk



Picture 4. The Observation Desk

C. Sample Determination

Pre-determined five levels of illumination, three levels of contrast and three levels of task detail size required minimum forty-five treatment combinations. Therefore, in order to test all the main effects in two complete replications of each treatment total ninety subjects were needed.

The subjects were selected among the second, third and fourth year Industrial Engineering students of 1977-78 academic year. A search among the student lists showed that there were 189 students in II., III., and IV. years and 93% (176) of these students were of ages between twenty and twenty-six. Altogether ninety students among the group of 176 were selected for the experiment randomly. Randomization was realized through simple procedure of appointment system. There were fifteen possible test days. An invitation to all the subjects was made and the appointments were scheduled the way the students desired. Each subject was asked to draw a number from a box in order to determine the treatment combination he (she) is going to be tested with.

Before conducting the experiment, all of the subjects were tested for their visual functions. The instrument of choice was Bausch and Lomb Ortho-Rater, visual function tester.

The test included:

- a) Far Vision Phoria Vertical
- b) Far Vision Phoria Lateral
- c) Far Vision Acuity Both Eyes
- d) Far Vision Acuity Right Eye
- e) Far Vision Acuity Left Eye
- d) Depth Perception
- g) Color Perception
- h) Near Vision Acuity Both Eyes
- i) Near Vision Acuity Right Eye
- j) Near Vision Acuity Left Eye
- k) Near Vision Phoria Vertical
- l) Near Vision Phoria Lateral

The findings after these tests are summarized in Chapter V and the complete list of the individual data summarized (Appendix D).

D. Ortho-Rater Testing

1. The Instrument

The instrument named Ortho-Rater is essentially a highly specialized Brewster Stereoscope which makes it possible to obtain optically any predetermined testing distance and control what each eye sees. In the Ortho-Rater the distance tests are made with the line of sight lowered 15 degrees from

the horizontal position. This is the normal posture for an individual directing attention to a distant object. The near testing distance is about 13 inches, representing an average near point job working distance. For the near point tests, the observer drops his line of sight another 20 degrees so that these tests are seen at normal reading posture. This position also provides assurance that the bifocal wearer will look through the reading portion of his lenses.

The Ortho-Rater is designed to provide a test situation which is equivalent to the usual 20 foot testing aisle needed for wall chart testing. These test conditions actually exist in the instrument with the testing distance accomplished by optical means.

The test slides are glass transparencies correctly positioned with respect to the lenses so as to obtain the proper testing distance without instrument adjustment. In use, each test slide is transilluminated. This method of illumination provides constant control of the intensity, since extraneous light from the testing room can not affect the total illumination on the slides.

2. Ortho-Rater Testing

Twelve important visual characteristics are tested with the Ortho-Rater. These are the functions which have been

proved most closely related to seeing tasks on the job. The tests fall under four basic classifications:

- a) Phoria, or binocular action of the eyes (vertical and lateral at both testing distances-four tests). These tests measure the tendency of the eyes to turn in or out, up or down when the stimulus to fusion is low.
- b) Acuity, or fineness of visual discrimination (both eyes, right and left eye at both testing distances-six tests).
- c) Stereopsis, or perception of depth (at distance-one test). The test aims at measuring the ability to judge distances.
- d) Color discrimination (at distance-one test).

CHAPTER V

STATISTICAL DESIGN OF THE EXPERIMENT

A. General Model

Assuming that factors A, B, C have a, b, c levels consecutively and each of the a.b.c cells is run in r replications. Thus N, the size of the experiment is $N = a.b.c.r$ and this a three-factor factorial experiment with r repetitions of each treatment combination.

The mathematical model for this experiment can be given as:

$$Y_{ijks} = \mu + \alpha_i + \beta_j + \gamma_k + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} + \epsilon_{ijks}$$

where $i:1,2,\dots,a$, $j:1,2,\dots,b$, $k:1,2,\dots,c$, $s:1,2,\dots,r$

Here, Y_{ijks} represents the response to the i^{th} level of A factor, j^{th} level of B factor, k^{th} level of C factor and s^{th} replication.

μ represents the overall true mean

α_i represents the true effect of the i^{th} level of A measured from μ

β_j represents the true effect of the j^{th} level of B measured from μ

γ_k represents the true effect of the k^{th} level of C measured from μ

$(\alpha\beta)_{ij}$ represents the true interaction effect of the i^{th} level of A with j^{th} level of B

$(\alpha\gamma)_{ik}$ represents the true interaction effect of the i^{th} level of A
with k^{th} level of C

$(\beta\gamma)_{jk}$ represents the true interaction effect of the j^{th} level of B
with k^{th} level of C

$(\alpha\beta\gamma)_{ijk}$ represents the true triple interaction effect of the i^{th}
level of A with the j^{th} level of B and with the k^{th} level of C.

ϵ_{ijks} represents the random error associated with Y_{ijks}

We assume that the error, ϵ_{ijks} is normally and independently
distributed with mean zero and common variance σ^2 . In another
words, $\epsilon_{ijks} \sim N(0, \sigma^2)$

When Model II is chosen in the analysis it is assumed that
all the components except the overall mean are random variates.
The treatments are assumed to be a random sample drawn from a
larger population of treatments. This population of treatments
is assumed to be infinitely large and to be normally distributed
with expected value zero and a treatment variance.

Assuming Model II (Model of random effects) gives rise to
statement of following assumptions and constraints for the
mathematical model:

$$\alpha_i \sim N(0, \sigma_A^2) \text{ for factor A}$$

$$\beta_j \sim N(0, \sigma_B^2) \text{ for factor B}$$

$$\gamma_k \sim N(0, \sigma_C^2) \text{ for factor C}$$

$(\alpha\beta)_{ij} \sim N(0, \sigma_{AB}^2)$ for AxB interaction

$(\alpha\gamma)_{ik} \sim N(0, \sigma_{AC}^2)$ for AxC interaction

$(\beta\gamma)_{jk} \sim N(0, \sigma_{BC}^2)$ for BxC interaction

$(\alpha\beta\gamma)_{ijk} \sim N(0, \sigma_{ABC}^2)$ for AxBxC interaction

If we denote the estimate of the different factors with a 'hat' on top of the letter ($\hat{\cdot}$), then the estimated response can be written as:

$$\hat{Y}_{ijks} = \hat{\mu} + \hat{\alpha}_i + \hat{\beta}_j + \hat{\gamma}_k + (\hat{\alpha}\hat{\beta})_{ij} + (\hat{\alpha}\hat{\gamma})_{ik} + (\hat{\beta}\hat{\gamma})_{jk} + (\hat{\alpha}\hat{\beta}\hat{\gamma})_{ijk}$$

Further, let:

$$\{A_i\} = \sum_j \sum_k \sum_s Y_{ijks}$$

$$\{A_i B_j\} = \sum_k \sum_s Y_{ijk}$$

$$\{B_j\} = \sum_i \sum_k \sum_s Y_{ijks}$$

$$\{A_i C_k\} = \sum_j \sum_s Y_{ijks}$$

$$\{C_k\} = \sum_i \sum_j \sum_s Y_{ijks}$$

$$\{B_j C_k\} = \sum_i \sum_s Y_{ijks}$$

$$\{A_i B_j C_k\} = \sum_s Y_{ijks}$$

and also:

$$\bar{Y}_{i\dots} = \frac{\{A_i\}}{bcr} ; \bar{Y}_{.j\dots} = \frac{\{B_j\}}{acr} ; \bar{Y}_{\dots k} = \frac{\{C_k\}}{abr} ; \bar{Y}_{ij\dots} = \frac{\{A_i B_j\}}{cr} ;$$

$$\bar{Y}_{i.k.} = \frac{\{A_i C_k\}}{br} ; \bar{Y}_{.jk.} = \frac{\{B_j C_k\}}{ar} ; \bar{Y}_{ijk.} = \frac{\{A_i B_j C_k\}}{r} ; \bar{Y} = \frac{G}{abcr} = \frac{G}{N}$$

The Least Square Estimates of the parameters in the model is obtained by minimizing the sum of squares of errors subject to the given constraints or, in another words:

$$\text{Minimize } \left\{ \sum_i \sum_j \sum_k \sum_s (Y_{ijks} - \alpha_i - \beta_j - \gamma_k - (\alpha\beta)_{ij} - (\alpha\gamma)_{ik} - (\beta\gamma)_{jk} - (\alpha\beta\gamma)_{ijk})^2 \right\}$$

Thus, the estimates for the parameters can be given as:

$$\hat{\mu} = \bar{Y}$$

$$\hat{\alpha}_i = \bar{Y}_{i\dots} - \bar{Y}$$

$$\hat{\beta}_j = \bar{Y}_{.j\dots} - \bar{Y}$$

$$\hat{\gamma}_k = \bar{Y}_{\dots k} - \bar{Y}$$

$$(\hat{\alpha\beta})_{ij} = \bar{Y}_{ij\dots} - \bar{Y}_{i\dots} - \bar{Y}_{.j\dots} + \bar{Y}$$

$$(\hat{\alpha\gamma})_{ik} = \bar{Y}_{i.k\dots} - \bar{Y}_{i\dots} - \bar{Y}_{\dots k} + \bar{Y}$$

$$(\hat{\beta\gamma})_{jk} = \bar{Y}_{.jk\dots} - \bar{Y}_{.j\dots} - \bar{Y}_{\dots k} + \bar{Y}$$

$$(\hat{\alpha\beta\gamma})_{ijk} = \bar{Y}_{ijk\dots} - \bar{Y}_{ij\dots} - \bar{Y}_{i.k\dots} - \bar{Y}_{.jk\dots} - \bar{Y}_{i\dots} - \bar{Y}_{.j\dots} - \bar{Y}_{\dots k} + \bar{Y}$$

When correction factor C is given by

$$C = \left(\sum_i \sum_j \sum_k \sum_s Y_{ijks} \right)^2 / N = G^2 / N$$

then Sum of Squares can be computed by using following formulas:

$$\text{TSS} = \sum_i \sum_j \sum_k \sum_s (Y_{ijks})^2 - C \equiv \sum_i \sum_j \sum_k \sum_s (Y_{ijks} - \bar{Y})^2$$

$$\text{SSA} = \frac{1}{\text{bcr}} \left\{ \sum_i \{A_i\}^2 \right\} - C \equiv \text{bcr} \sum_i (Y_{i\dots} - \bar{Y})^2 \equiv \text{bcr} \sum_i \hat{\alpha}_i^2$$

$$SSB = \frac{1}{acr} \sum_j \{B_j\}^2 - C \equiv acr \sum_j (\bar{Y}_{.j..} - \bar{Y})^2 \equiv acr \sum_j \hat{\beta}_j^2$$

$$SSC = \frac{1}{abr} \sum_k \{C_k\}^2 - C = abr \sum_k (\bar{Y}_{..k.} - \bar{Y})^2 \equiv abr \sum_k \hat{\gamma}_k^2$$

$$\begin{aligned} SS(AB) &= \frac{1}{cr} \sum_i \sum_j \{A_i B_j\}^2 - C - SSA - SSB \\ &\equiv cr \sum_i \sum_j (\bar{Y}_{ij..} - \bar{Y}_{i...} - \bar{Y}_{.j..} + \bar{Y})^2 \equiv cr \sum_i \sum_j (\hat{\alpha\beta})_{ij}^2 \end{aligned}$$

$$\begin{aligned} SS(AC) &= \frac{1}{br} \sum_i \sum_k \{A_i C_k\}^2 - C - SSA - SSC \\ &\equiv br \sum_i \sum_k (\bar{Y}_{i.k.} - \bar{Y}_{i...} - \bar{Y}_{..k.} + \bar{Y})^2 \equiv br \sum_i \sum_k (\hat{\alpha\gamma})_{ik}^2 \end{aligned}$$

$$\begin{aligned} SS(BC) &= \frac{1}{ar} \sum_j \sum_k \{B_j C_k\}^2 - C - SSB - SSC \\ &\equiv ar \sum_j \sum_k (\bar{Y}_{.jk.} - \bar{Y}_{.j..} - \bar{Y}_{..k.} + \bar{Y})^2 \equiv ar \sum_j \sum_k (\hat{\beta\gamma})_{jk}^2 \end{aligned}$$

$$\begin{aligned} SS(ABC) &= \frac{1}{r} \sum_i \sum_j \sum_k \{A_i B_j C_k\}^2 - C - SSA - SSB - SSC - SS(AB) - SS(AC) - SS(BC) \\ &\equiv r \sum_i \sum_j \sum_k (\bar{Y}_{ijk.} - \bar{Y}_{i...} - \bar{Y}_{.j..} - \bar{Y}_{..k.} - \bar{Y}_{ij..} - \bar{Y}_{i.k.} - \bar{Y}_{.jk.} + \bar{Y})^2 \\ &\equiv r \sum_i \sum_j \sum_k (\hat{\alpha\beta\gamma})_{ijk}^2 \end{aligned}$$

$$\begin{aligned} SS(ERROR) &= TSS - SSA - SSB - SSC - SS(AB) - SS(AC) - SS(BC) - SS(ABC) \\ &\equiv \sum_i \sum_j \sum_k \sum_s (Y_{ijks} - \bar{Y}_{ijk.})^2 \end{aligned}$$

The calculations can be summarized on the following ANOVA table
(Table 2) (27):

Table 2. Analysis of Variance (ANOVA)

SOURCE	DEG. Of Freedom	SS	MS	E (MS)	F'
Main effect A	f_A (a-1)	SSA	SSA/ f_A	$\sigma^2 + r\sigma_{ABC}^2 + r\sigma_{AB}^2 + r\sigma_{AC}^2 + rbc\sigma_A^2$	$\frac{MSA + MS(ABC)}{MS(AB) + MS(AC)}$
Main effect B	f_B (b-1)	SSB	SSB/ f_B	$\sigma^2 + r\sigma_{ABC}^2 + r\sigma_{AB}^2 + r\sigma_{BC}^2 + rac\sigma_B^2$	$\frac{MSB + MS(ABC)}{MS(AB) + MS(BC)}$
Main effect C	f_C (c-1)	SSC	SSC/ f_C	$\sigma^2 + r\sigma_{ABC}^2 + r\sigma_{AC}^2 + r\sigma_{BC}^2 + rab\sigma_C^2$	$\frac{MSC + MS(ABC)}{MS(AC) + MS(BC)}$
AB interaction	f_{AB} (a-1)(b-1)	SS(AB)	SS(AB)/ f_{AB}	$\sigma^2 + r\sigma_{ABC}^2 + r\sigma_{AB}^2$	$\frac{MS(AB)}{MS(ABC)}$
AC interaction	f_{AC} (a-1)(c-1)	SS(AC)	SS(AC)/ f_{AC}	$\sigma^2 + r\sigma_{ABC}^2 + r\sigma_{AC}^2$	$\frac{MS(AC)}{MS(ABC)}$
BC interaction	f_{BC} (b-1)(c-1)	SS(BC)	SS(BC)/ f_{BC}	$\sigma^2 + r\sigma_{ABC}^2 + r\sigma_{BC}^2$	$\frac{MS(BC)}{MS(ABC)}$
ABC interaction	f_{ABC} (a-1)(b-1)(c-1)	SS(ABC)	SS(ABC)/ f_{ABC}	$\sigma^2 + r\sigma_{ABC}^2$	$\frac{MS(ABC)}{SS(Error)}$
Residual (Error)	abc(r-1)	SSE	s_e^2	σ^2	
TOTAL	abc(r-1)	TSS			

B. Response Curve Analysis

If the levels of the factors represent increasing amount of some substance, say X, it may be of interest to examine whether the response Y to the factors has a polynomial relation to the amount X. This can be done if the factors are quantitative and the levels are of equal spacings. In this case, orthogonal polynomials are used. When the main effect of a quantitative factor is found to be significant, depending on the number of levels of the factor, the sum of squares of the main effect can be subdivided into linear, quadratic, cubic, quartic, etc. components. These component effects can be tested separately and the significance of them can be calculated. Thus, the polynomial regression of Y on X can be given in the form:

$$Y = B_0 + B_1X_1 + B_2X_2 + \dots + \epsilon$$

where B_i 's are the polynomial coefficients and are estimated by using component values which are found to be significant. The analysis of polynomial regression is based on linear regression. The theory of polynomial regression is explained fully in (27) by Snedecor and Cochran.

C. 5×3^2 Factorial Design Chosen

As seen in Chapter IV Section C, the factors to be tested in this study are:

Factor A: Illumination Level $a = 5$

Factor B: Brightness Contrast $b = 3$
 Factor C: Task Detail Size $c = 3$
 R: Repetitions $r = 2$

The skeleton of the ANOVA table for this model (5×3^2 factorial design in two replications) is given below:

Table 3. Analysis of Variance

Source of variation	Degrees of freedom
Illumination (A)	4
Contrast (B)	2
Task size (C)	2
Interaction Ill. x Cont. (AxB)	8
Interaction Ill. x Task s. (AxC)	8
Interaction Cont. x Task s. (BxC)	4
Interaction Ill. x Cont. x Task s. (AxBxC)	16
Residual (Error)	45
TOTAL	89

In this case, due to the nature of the problem, we assumed that the factors are of Model II type, which is also named as Model of Random Effects. It was clear that all three factors are quantitative, continuous variables of which only samples were taken as levels.

A response curve analysis was planned for the significant

factors and significant interaction effects. Through such an analysis, an orthogonal polynomial, of degree four for illumination and of degree two for the two other factors will be fitted. The significant interaction will be included as well in this polynomial.

D. Computer Programs Available for Analysis

A computer program from Scientific Subroutine Package (SSP) named ANOV was available for access at the Computer Center of METU. It was possible to produce factor levels, grand mean analysis of variance table with this program. The analysis of variance table included sum of squares, degrees of freedom and mean squares for main effects and their interactions. Further analysis, including test for significance and response curve analysis for significant effects had to be done manually. The main program ANOV utilized three subroutines from SSP during execution, namely AVDAT, AVCAL, and MEANQ. The program was based on methodology advised by Hartley (1962) (17).

CHAPTER VI

FINDINGS

A- Analysis of the Sample

The following two tables are given with an attempt to check for any bias in the two replications in terms of age and sex.

Table 4. Year of Birth of the Subjects by Replication

Year	Replication 1		Replication 2		TOTAL	
	N	%	N	%	N	%
1952	7	16	3	7	10	11
1953	5	11	5	11	10	11
1954	8	18	2	4	10	11
1955	6	13	13	29	19	21
1956	9	20	13	29	22	25
1957	8	18	7	16	15	17
1958	2	4	2	4	4	4
TOTAL	45	100	45	100	90	100

Table 5. Sex of the Subjects by Replication

Sex	Replication 1		Replication 2		TOTAL	
	N	%	N	%	N	%
Male	35	78	34	76	69	77
Female	10	22	11	24	21	23
TOTAL	45	100	45	100	90	100

B. Analysis of the Performance Rates for All Factors

The following 5 tables give the performance rate for the three factors to be studied. The performance rate has been discussed and defined in Chapter IV Section A (Appendix E).

Table 6. Mean and Standard Deviation of Performance by Illumination Levels

\bar{x} , SD	Illumination Levels				
	50 lux	300 lux	550 lux	800 lux	1050 lux
Mean Performance	46.81	49.97	44.43	47.85	49.60
Stand Deviation	7.34	8.56	4.66	8.64	7.11
Subjects (N)	18	18	18	18	18

Table 7. Mean and Standard Deviation of Performance by Contrast Values

\bar{x} , SD	Contrast Values		
	Offset print on 1 st quality paper	Offset print on 2 nd quality paper	Stencil print on 2 nd quality paper
Mean Performance	49.64	46.23	47.32
Stand Deviation	7.42	6.83	8.08
Subjects (N)	30	30	30

Table 8. Mean and Standard Deviation of Performance by
Task Detail Size

\bar{x} , SD	Task Detail Size		
	6 points	8 points	11 points
Mean Perform	44.60	48.41	50.18
Stand. Deviation	7.82	6.68	7.12
Subjects (N)	30	30	30

Table 9. Mean and Standard Deviation of Performance by
Illumination Levels and Task Detail Size*

Task Detail Size		Illumination Levels				
		50 lux	300 lux	550 lux	800 lux	1050 lux
6 points	Mean	48.82	44.51	42.69	46.80	45.20
	SD.	10.18	7.70	5.38	9.96	7.25
8 point	Mean	47.32	52.29	45.32	48.91	48.22
	SD.	4.66	10.39	4.36	7.44	4.83
11 points	Mean	49.30	53.10	45.27	47.85	55.36
	SD.	6.26	5.29	4.52	9.83	5.54

* Each figure is based on 6 observations.

Table 10. Mean and Standard Deviation of Performance by
Illumination Levels and Contrast Values [☆]

Contrast Values		Illumination Levels				
		50 lux	300 lux	550 lux	800 lux	1050 lux
Offset print on	M	48.25	53.21	44.41	51.08	51.23
1 st quality paper	SD	5.66	10.61	5.24	7.92	5.36
Offset print on	M	45.16	48.24	43.41	43.96	49.55
2 nd quality paper	SD	5.00	9.33	5.39	5.52	8.12
Stencil print on	M	46.19	48.46	45.46	48.51	48.00
2 nd quality paper	SD	11.09	5.54	3.86	11.38	8.43

☆ Each figure is based on 6 observations

C- Analysis of Eye Test Scores by Illumination Levels

Mean scores for the eye tests are given in Table 11. For the interpretation of the numbers given as eye test scores there exists equivalence tables (Appendix F).

Table 11. Mean and Standard Deviation of Eye Test Scores by Illumination Levels

Eye Test Scores	Illumination Levels						TOTAL
	50 lux	300 lux	550 lux	800 lux	1050 lux		
Near-Acuity	M	9.78	9.72	9.78	9.50	9.94	9.74
Both Eyes	SD	1.31	1.02	1.17	1.29	1.11	1.17
Near-Acuity	M	8.50	8.17	8.22	7.61	8.61	8.22
Right Eye	SD	1.34	0.92	1.77	1.29	1.29	1.32
Near-Acuity	M	9.61	9.00	9.22	8.11	9.67	9.12
Left Eye	SD	1.24	0.91	1.35	1.75	1.19	1.29
Near-Phoria-Vert.	M	3.33	3.42	3.60	3.91	3.55	3.56
Left High	SD	0.87	0.90	0.84	0.30	0.82	0.75
Near-Phoria-Vert.	M	5.33	5.00	5.50	5.00	5.14	5.19
Right Eye	SD	0.71	0.00	1.07	0.00	0.38	0.43
Near-Phoria-Lat.	M	3.75	2.60	4.25	4.50	4.67	3.95
Esophoric	SD	0.96	1.52	0.50	0.71	0.58	0.85
Near-Phoria-Lat.	M	8.43	8.62	8.50	7.94	8.40	8.38
Exophoric	SD	1.34	1.80	2.82	1.48	1.88	1.86
Subjects (N)		18	18	18	18	18	90

D- Analysis of Variance for the Performance Rates

As stated before, performance rates are taken as the total number of letters "e" and "a" detected correctly over the duration of the correction work. The correlation coefficient between the performance rates of page one and page two was 0.83. This can be considered as a high correlation. Due to this high correlation, it was decided to use, as the performance rate for any further analysis, the total, correctly marked letters "e" and "a" of both sheets together, divided by their total duration.

According to the formulation given in Chapter V. Section A, the sum of squares, mean sum of squares and the results of the F-tests can be summarized in Table 12. The significant effects at a 5 % confidence level are shown with a star.(☆)

Table 12. Analysis of Variance for the Performance Rates ⁺

Source	df	SS	MS	F'
Illumination	4	364.90	91.23	2.94 [☆]
Contrast	2	181.37	90.68	3.36 [☆]
Task Size	2	486.67	243.34	5.30 [☆]
Illum.X Contrast	8	131.95	16.49	0.36
Illum.X Task Size	8	242.96	30.37	0.66
Contrast X Task Size	4	97.25	24.31	0.52
Illum.X Contrast X Task S.	16	741.42	46.34	0.75
Residual (Error)	45	2777.90	61.73	
TOTAL	89	5024.43		

+ For interpretation see Table 2.

☆ At 0,05 significance level.

E- Response Curve Analysis of Significant Effects

It was decided to find the response curves for the main effects only. This was done because none of the interactions was significantly different from zero.

The analysis was simplified even further by finding two separate response curves, one for the illumination level and the other for the task detail size. No curve was fitted to the contrast levels, and this because the contrast value, though a quantitative variable, could not be measured by the researcher.

1. Response Curve for Illumination Levels

As this factor had five levels, the linear, quadratic, cubic, and quartic components had to be derived. The orthogonal independent variables, the components, the sum of squares, and the calculated F for every level of the polynomial is produced in the table below (27). It should be noted that each mean performance rate is based on 18 observations ($n=18$). As before, the significant coefficients, at a significance level of 0.05 are shown by a star next to the relevant F value.

Table 13. Response Curve Analysis for the Illumination Levels

	Illumination Levels (lux)					Component	SS	F
	50	300	550	800	1050			
Mean Yields	46.81	49.97	44.43	47.85	49.60			
Linear	-2	-1	0	+1	+2	+3.46	21.55	0.35
Quadratic	+2	-1	-2	1	+2	+6.14	48.47	0.79
Cubic	-1	+2	0	-2	+1	+7.03	88.96	1.44 [☆]
Quartic	+1	-4	+6	-4	+1	-28.29	205.80	3.33 [☆]

Total SS for illumination levels 364.78

Error Mean Square (45 df) = 61.73

As seen in Table 13, linear and quadratic coefficients are not significant but cubic and quartic components are significantly different from zero.

$$\bar{Y} = 47.73$$

$$b_3 = 0.703 \quad b_4 = 0.400$$

Therefore, the response curve takes the form :

$$\hat{Y} = 47.73 + 0.703 x_3 - 0.400 x_4 \quad (6.1)$$

By using the regression equation 6.1 it is possible to estimate performance rates for each illumination level.

Table 14. Estimated and Observed Performance Rates for Each Illumination Level

Illum Level	Estimated P.	Observed P.
50 lux	46.63	46.81
300 lux	50.74	49.97
550 lux	45.33	44.43
800 lux	47.92	47.85
1050 lux	48.03	49.60

2. Response Curve for Task Detail Size

A similar analysis was done for task detail size. Due to the fact that the task detail size effect has three levels, a polynomial of degree two can be fitted. The results are given in the table below. It should be noted that every mean performance rate is based on 30 observations.

Table 15. Response Curve Analysis for the Task Detail Size

	Task Detail Size			Component	SS	F
	6p	8p	11p			
Mean Yields	44.60	48.41	50.18			
Linear	-1	0	+1	+5.58	467.50	7.37 [☆]
Quadratic	+1	-2	+1	-2.04	20.81	0.34

Total SS for task detail size 488.31

Error Mean Square (45 df)= 61.73

As seen in Table 15, only the linear coefficient is significantly different from zero at a significance level of 0,05

$$\bar{Y} = 47.73$$

$$b_1 = +2.79$$

Therefore, the response curve takes the form :

$$\hat{Y} = 47.73 + 2.79 x_1 \quad (6.2)$$

Similarly, by using the regression equation 6.2 it is possible to estimate performance rates for each task detail size.

Table 16. Estimated and Observed Performance Rates for
Each Task Detail Size

<u>Task Detail Size</u>	<u>Estimated P.</u>	<u>Observed P.</u>
6 points	44.94	44.60
8 points	47.73	48.41
11 points	50.52	50.18

CHAPTER VII

DISCUSSIONS

A detailed study of the findings show that with great probability the discrepancy between hypothesized and expected performances were due to the limited number of subjects tested on each replica and task detail size. On the other hand, the use of city current and lowering the voltage for low levels of illumination brought about a problem of color change in the room which changed the comfort of letter selection to a great extent.

The use of a VARIAC for different levels of illumination was decided during the design phase of the simulation room. There were no complaints on the part of the subjects about the color effect which resulted from changes of voltage, but a careful opinion survey after the completion of the experiments obviated the permanent presence of a yellowish color in the room which may have affected the visual performance of the subjects. The subjects were easily motivated to do whatever the researcher asked them to do. They just did their best and accepted the illumination conditions as the natural conditions predetermined by the researcher. However, a change of design and illumination specifications was not attempted even after the treatment of data. Before any attempt of similar research, simulation of different levels of illumination should be

re-considered and the color change be eliminated. This was the first important observation after this short term research. White- day light- simulation seems to be essential for such approaches.

The sampling method did not permit any bias of age, sex, visual capacity or any other variable between the replication groups. This fact is shown in Tables 4 and 5. The researcher did not hesitate in including both sexes to the test population as to simulate real life conditions. Although age has been determined to be an important factor in case of a great range of ages (6,26), this factor was almost nullified by the selection of young university students of ages 20-26, and under these circumstances the differences between the ages of the subjects were assumed to be not affecting their performances.

Analysis of the performance rates of the subjects for different illumination levels did not verify the hypothesis. It seems that the performances reach their maximum value at 300 lux illumination level. An increase of 250 lux results in a decline in the performance and further increases of 250 lux illumination increases the performance but to a lower level than the level at 300 lux illumination. An illumination level of 300 lux resulted in better performances under the present simulation conditions (Table 6).

For different contrast values, highest performance have been obtained for offset-print text on first quality paper. Stencil-print on second quality paper resulted in next highest performance in the correction work (Table 7). The stencils had higher contrast in comparison to offset print on the same quality papers. This verifies the importance of contrast in visual task performances.

Mean performance of the subjects was least for the text of 6-point task detail size and it increased as the task detail size increased (Table 8).

For all three factors, it can be accepted that there are differences in performance rates for different levels of each factor. There seems significant interaction between illumination levels and task detail size (Table 9), and illumination levels and contrast values (Table 10) but it was shown that none of these interactions were significant at 0,05 level of significance (Table 12).

Eye test scores for near vision have been analyzed for subjects of each illumination level group. This analysis demonstrated that there seems no evidence that visual functions of the test groups differ significantly for each illumination level group (Table 11).

Analysis of variance table (Table 12) shows that each factor has a significant effect on the performance rate of the subjects at a 0,05 significance level. Furthermore, there

exists no interaction effects between the factors. Significance of the main effects enabled conducting response curve analysis. Through such an analysis, the regression equations 6.1 and 6.2 have been obtained. These equations can be used to predict performance rate for a given level of each factor separately.

One other point is that there exists a non-linear relationship between the level of illumination and performance rates. This nonlinear relationship, which was discussed earlier as possible outcome of color interference on the level of illumination, is characterized by equation 6.1.

The relation between the task detail size and performance rate is linear and this is shown by equation 6.2.

CHAPTER VIII

SUMMARY AND SUGGESTIONS

The use of a simulation room seems to be an economical and practical way of studying the different levels of illumination. The simulation approach to office illumination was applied to a limited number of subjects with a narrow age range. The technique used in the simulation of different levels of illumination introduced some undesirable effects. Within the technical limitations of this research however, a summary and several remarks about the findings seem to be warranted.

For the purpose of this research, three different task detail size and three different contrast values were considered satisfactory. With the given limitations, an office with 300 lux incident illumination seems to permit better performances in different contrast and task size letter selection jobs.

The findings suggest real life conditions simulation and simulations other than office illumination should be attempted. The duration of the experiments should be extended to hours or possibly to a full day's testing. Illumination system for such simulations should be obtained through change of number of light bulbs instead of using VARIAC control.

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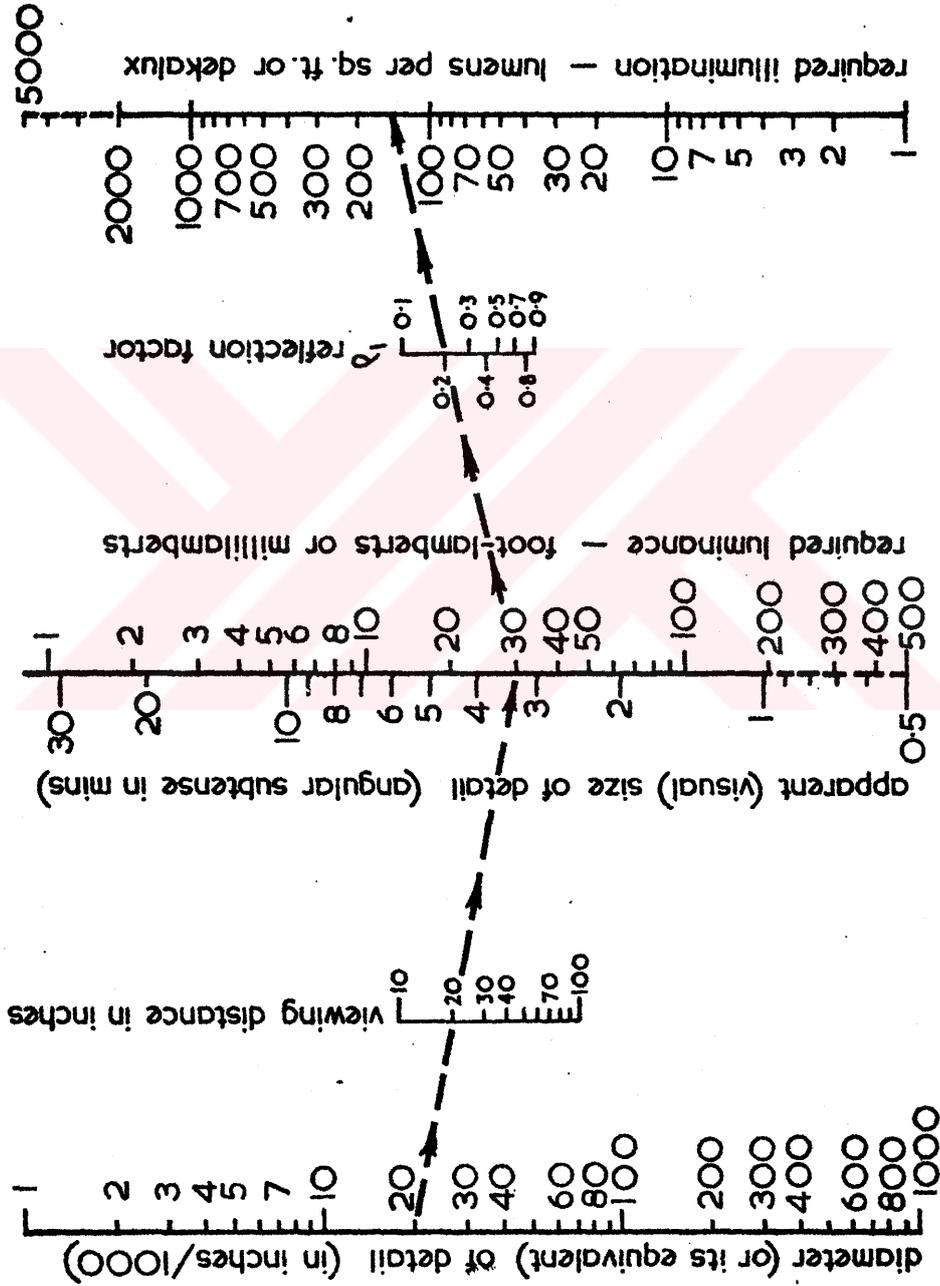
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A P P E N D I X A
N O M O G R A M O F W E S T O N ' S A P P R O A C H



APPENDIX A
 NOMOGRAM OF WESTON'S APPROACH



Nomogram for finding the desirable working illumination for any visual task on the basis of the actual size of the critical detail that must be seen, the distance of this detail from the viewer and the reflectance taken as indicating the lightness of the object of view. (The metric unit of illumination is the lumen per sq. metre, named "lux", 10 lux, i.e., 1 dekalux = 1 lm/ft² approx.)

A P P E N D I X B
V I S U A L T A S K S M O S T L Y U S E D



A P P E N D I X B
V I S U A L T A S K S M O S T L Y U S E D



Five visual tasks used for comparative measurements, black on matte white background. Size of disc approximately 4-minutes.

A P P E N D I X C
COMPARATIVE VALUES FOR REFLECTANCE
RATE OF THE TEST PAGES



Comparative Values for Reflectance Rate of the Test Pages

Contrast Value	Task Size	Illumination Levels					Mean
		50 Lux	300 Lux	550 Lux	800 Lux	1050 Lux	
Offset on 1 st (0.412)*	6 points	.48	.48	.42	.31	.39	0.416
	8 points	.48	.48	.41	.31	.39	0.414
	11 points	.46	.47	.41	.31	.38	0.406
Offset on 2 nd (0.386)*	6 points	.44	.45	.39	.30	.36	0.388
	8 points	.44	.45	.39	.30	.36	0.388
	11 points	.44	.44	.38	.29	.36	0.382
Stencil on 2 nd (0.389)*	6 points	.46	.45	.39	.30	.36	0.392
	8 points	.46	.45	.39	.30	.36	0.392
	11 points	.44	.44	.38	.29	.36	0.382

☆ Mean reflectance rate for the contrast level.

A P P E N D I X D
E Y E T E S T S C O R E S O F T H E S U B J E C T S



Eye Test Scores of the Subjects

Legend:

1. Rx : 1) None, 2) All, 3) Bifocal, 4) Far, 5) Near, 6) Irregular
2. Far Vision Phoria Vertical
3. Far Vision Phoria Lateral
4. Far Vision Acuity Both Eyes
5. Far Vision Acuity Right Eye
6. Far Vision Acuity Left Eye
7. Depth Perception
8. Color Perception
9. Near Vision Acuity Both Eyes
10. Near Vision Acuity Right Eye
11. Near Vision Acuity Left Eye
12. Near Vision Phoria Vertical
13. Near Vision Phoria Lateral

EYE TEST SCORES OF THE SUBJECTS

No.	Subject	1	2	3	4	5	6	7	8	9	10	11	12	13
1	T.T.	4	5	8	8	8	7	4	2	10	9	9	2	9
2	M.E.	4	6	9	5	5	6	4	2	10	8	10	5	3
3	Y.E.	1	7	6	8	8	7	5	2	10	8	10	5	5
4	B.Ö.	1	6	7	9	8	8	2	1	10	6	9	4	6
5	E.A.	1	6	10	6	5	5	2	2	12	9	11	4	7
6	C.A.	4	7	7	8	6	7	1	2	10	11	8	7	8
7	F.T.	4	6	7	8	6	7	9	2	9	8	9	4	2
8	A.D.	1	5	5	10	8	9	9	2	9	8	9	4	7
9	M.Y.	1	8	6	4	4	5	1	2	10	7	9	5	6
10	Ö.S.	1	6	9	9	6	7	6	1	8	7	7	2	9
11	G.A.	1	6	6	10	10	8	5	3	11	9	11	5	9
12	G.G.	1	6	9	10	5	8	4	2	10	8	10	5	7
13	M.M.	1	5	3	7	5	7	6	2	9	7	9	5	9
14	E.B.	1	5	7	8	10	8	2	2	9	10	8	3	9
15	N.S.	4	7	9	7	7	7	5	2	9	8	7	5	13
16	H.K.	4	5	10	4	5	4	3	2	6	5	7	4	4

(Continued)

No.	Subject	1	2	3	4	5	6	7	8	9	10	11	12	13
17	N.P.	4	6	7	7	5	7	6	2	9	8	8	5	9
18	R.E.	1	6	9	10	9	10	9	2	10	8	9	4	4
19	H.M.	4	6	9	7	3	6	5	2	9	7	8	4	8
20	Ö.Ş.	4	7	7	6	5	7	7	3	10	9	10	5	4
21	T.A.	1	6	9	8	8	10	9	2	12	8	10	4	7
22	B.G.	1	5	3	8	6	7	1	1	9	8	9	4	5
23	M.B.	1	8	6	4	2	4	2	4	7	5	6	2	15
24	Ö.D.	1	7	10	7	7	7	5	2	8	8	7	5	9
25	H.Y.	1	6	7	10	8	9	7	2	11	10	10	5	9
26	Ş.Ö.	1	5	7	8	7	8	9	2	11	8	9	5	7
27	N.E.	1	6	2	7	5	5	5	2	9	9	8	5	1
28	N.C.	4	3	4	4	3	3	6	1	10	8	9	4	7
29	D.B.	4	6	5	7	7	8	6	2	11	9	9	5	4
30	C.D.	1	5	12	7	7	7	6	2	10	7	9	4	5
31	A.İ.	1	6	8	8	6	7	8	2	9	7	8	2	5
32	Z.S.	4	6	11	5	4	5	5	2	9	9	9	4	11

(Continued)

No.	Subject	1	2	3	4	5	6	7	8	9	10	11	12	13
33	S.Y.	4	6	7	6	7	7	7	3	10	8	9	4	7
34	F.D.	1	6	4	10	9	6	8	1	12	8	8	4	8
35	H.Ç.	1	6	10	11	8	11	9	2	10	10	11	4	6
36	A.M.	1	6	7	7	5	6	3	2	10	9	10	5	8
37	M.A.	4	5	8	9	8	8	6	2	9	7	9	3	7
38	M.S.	1	6	11	7	6	7	1	1	9	6	9	5	11
39	I.K.	1	5	7	9	9	9	7	3	10	9	10	4	10
40	A.T.	1	6	10	6	5	4	2	3	8	8	9	6	11
41	L.B.	1	6	8	7	4	7	9	1	9	7	9	4	9
42	N.P.	1	6	7	7	8	7	1	2	10	8	7	4	6
43	H.Ç.	1	7	9	7	8	7	9	1	10	9	10	4	4
44	I.G.	4	6	6	6	5	7	6	2	8	6	7	5	6
45	M.D.	1	8	6	8	7	6	2	2	11	8	10	5	7
46	R.O.	1	5	13	9	10	9	4	1	11	9	10	3	11
47	N.K.	1	6	11	3	2	3	3	2	10	8	9	3	9
48	H.Y.	1	7	8	8	8	7	5	1	11	10	9	5	6

(Continued)

No.	Subject	1	2	3	4	5	6	7	8	9	10	11	12	13
49	T.T.	4	5	6	6	6	5	3	2	11	6	9	4	9
50	M.K.	1	2	9	6	3	5	3	2	10	6	10	5	8
51	S.K.	1	6	13	8	8	8	9	2	10	8	9	5	3
52	N.Ç.	1	5	3	10	7	10	5	2	12	10	10	3	8
53	F.A.	1	7	11	9	8	9	1	2	11	9	10	8	13
54	H.G.	1	6	10	11	5	9	6	2	9	8	9	4	8
55	N.Ö.	1	8	9	10	10	10	9	2	10	9	10	4	8
56	B.U.	1	5	8	9	5	7	4	4	9	9	10	4	8
57	A.A.	1	5	10	8	8	9	8	2	12	8	10	3	11
58	A.T.	1	6	5	9	7	7	8	2	10	12	8	4	8
59	Ö.E.	4	8	9	9	8	3	5	2	10	9	3	4	5
60	H.M.	1	5	5	8	7	7	1	3	10	8	9	4	6
61	I.Ö.	1	6	7	7	7	7	7	2	9	8	9	6	7
62	Z.Ç.	4	6	10	8	8	7	9	2	9	8	8	4	12
63	T.A.	6	6	10	6	5	4	3	2	8	5	7	2	8
64	Ş.J.	4	7	8	5	5	4	5	2	7	8	5	5	8

(Continued)

No.	Subject	1	2	3	4	5	6	7	8	9	10	11	12	13
65	A.K.	4	6	12	5	6	4	1	1	10	10	11	4	8
66	B.A.	1	5	6	8	8	7	8	2	9	9	12	5	9
67	A.G.	1	6	8	6	7	7	1	2	11	8	10	5	9
68	S.U.	1	7	5	8	6	7	4	2	11	10	11	4	6
69	K.T.	4	5	6	6	6	7	1	2	8	6	8	4	9
70	M.A.	1	6	10	11	10	10	9	2	10	11	10	4	5
71	N.E.	4	6	6	7	5	7	5	1	10	10	11	4	3
72	S.A.	4	6	3	3	4	4	2	2	10	10	8	4	2
73	N.D.	1	7	1	7	6	7	6	2	10	8	10	6	6
74	B.M.	1	6	8	7	6	7	8	2	9	8	9	5	9
75	A.A.	4	6	8	9	8	9	3	2	9	9	9	2	7
76	V.A.	1	7	8	10	10	10	8	2	11	10	11	5	8
77	B.E.	1	4	9	6	5	8	7	2	9	8	9	1	8
78	M.E.	1	6	7	6	8	6	2	2	9	8	10	5	4
79	V.T.	1	5	5	8	8	5	6	2	11	9	10	5	6
80	I.Y.	1	6	9	10	10	6	5	2	9	10	10	5	8

(Continued)

No.	Subject	1	2	3	4	5	6	7	8	9	10	11	12	13
81	M.K.	1	6	6	10	5	7	4	2	9	9	10	3	7
82	E.O.	1	6	8	7	6	7	6	2	9	8	9	4	8
83	M.A.	1	5	9	12	10	11	9	3	12	9	9	4	10
84	S.E.	1	7	9	8	7	7	3	2	10	7	9	4	10
85	D.A.	1	6	10	8	6	9	8	3	12	8	11	3	9
86	F.B.	1	6	9	9	9	8	5	2	10	8	10	5	11
87	C.Ç.	1	6	6	9	7	8	7	2	9	6	10	4	7
88	B.D.	1	6	9	9	10	9	9	2	10	10	12	5	6
89	S.R.	4	5	6	5	5	5	4	2	9	6	9	4	6
90	Ç.S.	1	7	11	9	6	9	9	2	10	8	10	4	10

A P P E N D I X E

PERFORMANCE DATA OF THE SUBJECTS



Performance Data of the Subjects

Legend:

1. Year of Birth
 2. Class
 3. Sex
 4. Level of Factor A
 5. Level of Factor B
 6. Level of Factor C
 7. Repetition
 8. Number of "e" and "a" detected on page 1
 9. Number of "e" and "a" detected on page 2
 10. Duration of the experiment for page 1 (in min. s)
 11. Duration of the experiment for page 2 (in min. s)
- Total Number of "a" and "e" on page 1: 530
- Total Number of "a" and "e" on page 2: 497

PERFORMANCE DATA OF THE SUBJECTS

No	Subject	1	2	3	4	5	6	7	8	9	10	11.
1	T.T.	55	4	M	1	1	1	1	490	480	11.35	7.05
2	M.E.	57	3	M	2	1	1	1	511	486	9.55	8.30
3	Y.E.	54	4	M	3	1	1	1	517	483	13.35	10.90
4	B.O.	57	4	M	4	1	1	1	508	486	9.05	7.60
5	E.A.	58	3	M	5	1	1	1	512	491	10.40	9.65
6	C.A.	56	3	M	1	2	1	1	521	490	13.65	11.40
7	F.T.	53	4	M	2	2	1	1	497	473	15.85	13.70
8	A.D.	53	4	M	3	2	1	1	527	490	12.80	9.30
9	M.Y.	52	3	M	4	2	1	1	513	486	12.05	11.25
10	Ö.S.	52	4	M	5	2	1	1	485	477	10.85	11.05
11	G.A.	54	3	M	1	3	1	1	478	429	10.10	8.95
12	G.G.	54	3	F	2	3	1	1	500	471	11.10	9.50
13	M.M.	54	4	F	3	3	1	1	485	470	11.05	9.55
14	E.B.	56	3	M	4	3	1	1	479	438	19.70	10.00
15	N.S.	57	4	F	5	3	1	1	484	472	9.70	8.95
16	H.K.	54	5	M	1	1	2	1	504	463	13.70	11.20

(Continued)

No.	Subject	1	2	3	4	5	6	7	8	9	10	11
17	N.P.	52	4	M	2	1	2	1	502	426	11.20	8.90
18	R.E.	55	3	M	3	1	2	1	500	475	11.80	11.55
19	H.M.	56	4	M	4	1	2	1	522	491	10.00	8.70
20	Ö.Ş.	56	4	M	5	1	2	1	510	475	13.10	10.05
21	T.A.	58	3	M	1	2	2	1	520	475	10.40	8.60
22	B.G.	56	4	M	2	2	2	1	520	495	12.05	9.70
23	M.B.	54	4	M	3	2	2	1	519	492	10.31	9.61
24	Ö.D.	52	4	M	4	2	2	1	517	484	11.90	11.10
25	H.Y.	57	3	M	5	2	2	1	524	491	12.90	11.05
26	Ş.Ö.	54	3	M	1	3	2	1	512	484	10.75	10.10
27	N.E.	56	4	F	2	3	2	1	514	481	13.05	11.10
28	N.C.	57	3	F	3	3	2	1	519	480	12.95	12.05
29	D.B.	57	3	M	4	3	2	1	491	453	8.10	7.45
30	C.D.	56	3	M	5	3	2	1	522	487	10.00	9.25
31	A.İ.	53	3	M	1	1	3	1	515	483	11.85	10.05
32	Z.S.	53	4	M	2	1	3	1	508	465	9.05	7.80

(Continued)

No.	Subject	1	2	3	4	5	6	7	8	9	10	11
33	S.Y.	55	4	F	3	1	3	1	527	496	10.50	9.50
34	F.D.	56	3	F	4	1	3	1	510	478	8.95	7.85
35	H.Ç.	57	3	F	5	1	3	1	521	482	9.05	8.70
36	A.M.	56	3	M	1	2	3	1	525	494	11.90	11.90
37	M.A.	52	5	F	2	2	3	1	519	489	8.65	7.80
38	M.S.	52	4	F	3	2	3	1	509	480	13.12	12.50
39	I.K.	52	3	M	4	2	3	1	529	492	14.80	13.60
40	A.T.	55	4	M	5	2	3	1	504	488	11.10	9.55
41	L.B.	57	3	M	1	3	3	1	525	494	8.90	7.90
42	N.P.	54	3	M	2	3	3	1	514	484	10.45	9.45
43	H.Ç.	55	4	M	3	3	3	1	527	497	13.35	11.20
44	I.G.	55	4	M	4	3	3	1	508	475	9.70	7.00
45	M.D.	53	4	M	5	3	3	1	509	482	10.75	8.70
46	R.O.	55	4	M	1	1	1	2	505	491	9.45	9.05
47	N.K.	56	4	M	2	1	1	2	517	489	14.65	10.25
48	H.Y.	57	3	M	3	1	1	2	523	487	14.70	12.55

(Continued)

No.	Subject	1	2	3	4	5	6	7	8	9	10	11
49	T.T.	57	3	F	4	1	1	2	514	493	11.65	11.10
50	M.K.	56	4	M	5	1	1	2	522	482	11.16	9.30
51	S.K.	56	4	F	1	2	1	2	511	492	12.67	11.14
52	N.Ç.	57	3	M	2	2	1	2	505	487	11.30	9.75
53	F.A.	53	3	M	3	2	1	2	504	475	14.15	12.93
54	H.G.	56	3	M	4	2	1	2	526	487	11.10	9.42
55	N.Ö.	56	3	F	5	2	1	2	513	486	11.31	10.70
56	B.U.	52	4	M	1	3	1	2	483	461	18.94	17.05
57	A.A.	55	4	M	2	3	1	2	494	463	11.33	10.56
58	A.T.	53	4	M	3	3	1	2	481	453	9.90	9.05
59	Ö.E.	57	3	M	4	3	1	2	428	402	8.65	6.80
60	H.M.	55	4	M	5	3	1	2	451	453	15.40	13.25
61	I.Ö.	56	4	M	1	1	2	2	507	489	10.92	10.30
62	Z.Ç.	55	3	F	2	1	2	2	514	484	7.95	6.20
63	T.A.	57	3	M	3	1	2	2	512	478	10.90	10.05
64	Ş.J.	58	3	F	4	1	2	2	514	485	11.55	8.65

(Continued)

No.	Subject	1	2	3	4	5	6	7	8	9	10	11
65	A.K.	55	4	M	5	1	2	2	488	455	10.00	8.05
66	B.A.	53	5	M	1	2	2	2	487	479	10.20	8.90
67	A.G.	55	3	M	2	2	2	2	506	490	9.95	8.80
68	S.U.	54	3	M	3	2	2	2	506	480	11.72	11.22
69	K.T.	55	4	M	4	2	2	2	514	488	13.20	11.20
70	M.A.	56	4	M	5	2	2	2	517	488	9.75	9.05
71	N.E.	57	4	M	1	3	2	2	523	483	11.10	10.02
72	S.A.	55	3	M	2	3	2	2	500	481	9.75	7.75
73	N.D.	52	3	M	3	3	2	2	524	487	10.95	9.60
74	B.M.	53	4	M	4	3	2	2	522	494	12.10	10.61
75	A.A.	54	3	F	5	3	2	2	510	488	11.10	9.75
76	V.A.	56	3	F	1	1	3	2	522	486	10.83	8.70
77	B.E.	56	3	M	2	1	3	2	515	489	11.02	9.65
78	M.E.	55	3	M	3	1	3	2	518	476	10.84	9.88
79	V.T.	53	4	M	4	1	3	2	507	477	14.24	10.30
80	I.Y.	56	4	M	5	1	3	2	505	484	9.10	8.25

(Continued)

No.	Subject	1	2	3	4	5	6	7	8	9	10	11
81	M.K.	55	3	M	1	2	3	2	523	491	11.45	9.80
82	E.O.	52	4	M	2	2	3	2	516	486	10.70	10.00
83	M.A.	56	3	M	3	2	3	2	514	477	11.00	10.50
84	S.E.	57	3	F	4	2	3	2	513	494	10.65	9.10
85	D.A.	56	4	F	5	2	3	2	523	493	8.95	6.90
86	F.B.	56	3	F	1	3	3	2	522	489	10.75	10.56
87	C.Ç.	55	3	M	2	3	3	2	521	489	9.90	9.35
88	B.D.	55	4	M	3	3	3	2	529	497	11.95	10.25
89	S.R.	55	4	M	4	3	3	2	518	486	12.85	10.85
90	Ç.S.	58	3	F	5	3	3	2	515	485	9.45	8.55

A P P E N D I X F

ORTHO-RATER EQUIVALENCE TABLES



A P P E N D I X F

ORTHO-RATER EQUIVALENCE TABLES

PRISM DIOPTRER EQUIVALENTS OF ORTHO-RATER PHORIA SCORES

Score	Vertical Phoria (Prism Diopters)		Lateral Phoria (Prism Diopters)	
	Far	Near	Far	Near
1	2.0 LH	1.5 LH	+7.33	+6.0
2	1.5 LH	1.0 LH	+6.33	+4.5
3	1.0 LH	0.5 LH	+5.33	+3.0
4	0.5 LH	0.17 LH	+4.33	+1.5
5	0.17 LH	0.17 RH	+3.33	0
6	0.17 RH	0.5 RH	+2.33	-1.5
7	0.5 RH	1.0 RH	+1.33	-3.0
8	1.0 RH	1.5 RH	+0.33	-4.5
9	1.5 RH	2.0 RH	-0.66	-6.0
10			-1.66	-7.5
11			-2.66	-9.0
12			-3.66	-10.5
13			-4.66	-12.0
14			-5.66	-13.5
15			-6.66	-15.0

VISUAL ACUITY EQUIVALENTS OF ORTHO-RATER ACUITY LEVELS

Test Item Number	Visual Angle	Visual Acuity Notation		
		Decimal	Snellen	A.M.A.
1	10.0'	.1	20/200	20%
2	5.0'	.2	20/100	49%
3	3.33'	.3	20/67	67.5%
4	2.5'	.4	20/50	76.5%
5	2.0'	.5	20/40	84.5%
6	1.67'	.6	20/33	88.5%
7	1.43'	.7	20/29	92.5%
8	1.25'	.8	20/25	95.5%
9	1.11'	.9	20/22	98%
10	1.0'	1.0	20/20	100%
11	0.91'	1.1	20/18	101.5%
12	0.83'	1.2	20/17	103%

Master Ortho-Rater, Instructions, Bausch and Lomb Inc.
Rochester, New York 14602.

A P P E N D I X G

PHOTOMETRIC UNITS



APPENDIX G

PHOTOMETRIC UNITS

Property and definition	Unit	Symbol or abbreviation
The luminous flux Φ is the total visible energy emitted by a source of light. The bases for its evaluation are the <i>relative spectral sensitivity</i> V_λ^* of the eye adapted to bright light and the mechanical equivalent of light M^{**} .	lumen	lm
The quantity of light Q is the product of the luminous flux and its duration.	{ lumen second lumen hour	{ lms lmh
The luminous intensity I in a given direction is the relation between the luminous flux radiated in that direction and the area upon which it falls, i.e. luminous flux per unit area. The unit is the <i>candela</i> or international candle***. A source of light having a luminous intensity of one candela in all directions produces a luminous flux of 4π lumen.	candela	cd
The luminance (brightness) L of a surface in a given direction is the ratio of the luminous intensity in that direction to the orthogonal projection of the radiating surface in that direction.	{ stilb = cd/cm ² apostilb = sb/10 ⁴ π lambert = sb/ π = 10 ⁴ asb	{ sb asb La
The unit of brightness for scotopic vision , in contrast to the preceding units, is related to the eye adapted to vision in the dark (rod vision). The conversion factor between this and the luminance L depends on the composition of the light. The unit is used only up to 10 skot.	skot = 10 ⁻³ asb for radiation with a color temperature of 2360° K	sk
The specific luminous radiation H of a surface is the ratio of the radiated luminous flux to the area of the surface.	phot [†] = lm/cm ²	ph
The intensity of illumination E is the ratio of the luminous flux incident upon a surface to the area A of the surface ($E = \Phi/A$) and therefore corresponds to the specific radiation with respect to that part of the radiation reaching the surface illuminated. 1 lumen uniformly distributed over 1 square meter of surface produces an intensity of 1 lux.	lux = lm/m ²	lx
The unit of intensity of illumination for scotopic vision is analogous to that of brightness for scotopic vision, and relates to the eye adapted to vision in the dark.	nox = 10 ⁻³ lx for radiation with a color temperature of 2360° K	nx
The quantity of illumination is the product of the intensity of illumination and its duration.	lux second	lx s
The luminous efficiency of a source of light is the ratio of the total luminous flux emitted to the power absorbed.	lumen/watt	lm/W

* For the relative spectral sensitivity V_λ of the eye the following internationally recognized values are used (λ = wave-length of light in nanometers [millimicrons]):

λ	V_λ	λ	V_λ	λ	V_λ	λ	V_λ	λ	V_λ	λ	V_λ	λ	V_λ
400	0.0004	440	0.023	480	0.139	520	0.710	555	1.000	590	0.757	630	0.265
410	0.0012	450	0.038	490	0.208	530	0.862	560	0.995	600	0.631	640	0.175
420	0.0040	460	0.060	500	0.323	540	0.954	570	0.932	610	0.503	650	0.107
430	0.0116	470	0.091	510	0.503	550	0.995	580	0.870	620	0.381	660	0.061
												670	0.032
												710	0.0021
												720	0.00105
												730	0.00052
												740	0.00025
												750	0.00012
												760	0.00006

** The mechanical or electrical equivalent of light M is calculated for the lumen based on the candela as $M = (1.46, \pm 0.010) \times 10^{-3} \text{ J} \times (\text{s} \times \text{lm})^{-1} = (1.46, \pm 0.010) \times 10^{-3} \text{ W/lm}$, or $1/M = (680 \pm 5) \text{ lm/W}$. The new lumen therefore corresponds to a radiation of 0.00146 watt.

*** The candela is defined by the condition that the luminance L of a black-body radiator amounts to 60 candela per square centimeter at the temperature of solidifying platinum.

† The phot, which by definition is the unit of specific radiation, is frequently used as a unit of illumination. In this case 1 phot = 10⁴ lux.

* Documenta Geigy Scientific Tables, Konrad DIEM, ed.,
J.R. Geigy S.A., Basle, Switzerland, 1962.

A P P E N D I X H
EVALUATION FORM



Evaluation Form

No. _____

Name Surname Date / /19
Dept Year of birth 19 Class Sex level of A ()
Level of illumination lux level of B ()
Print type : Offset Stencil ; Paper used:lq ...2q level of C ()
Task detail size points
Total number of "e" and "a" Number of "e" and "a" detected :
Page 1 : 530 Page 2: 497 Page 1 : Page 2:
Grand total : 1027 Total Detected Performance 1) 2) T).....
Duration of the experiment (mins) : 1) 2) T) Repetition: 1 2
R_x : None; All; Bifocal; Far; Near; Irregular

R_x - 0 Far Vision

PHORIA	Vertical	0	1	2	3	4	5	6	7	8	9						
	Lateral	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ACUITY	Both	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Right	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Left	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Depth Perception		0	1	2	3	4	5	6	7	8	9						
Color Perception		0	1	2	3	4	5	6									

R_x - Near Vision

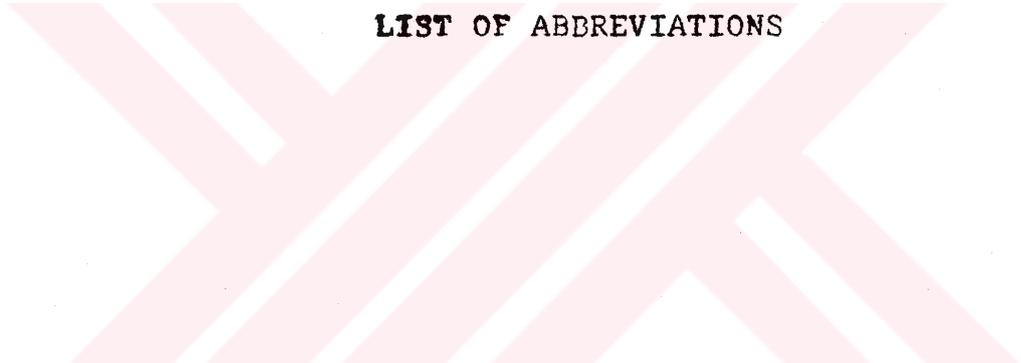
ACUITY	Both	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Right	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Left	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PHORIA	Vertical	0	1	2	3	4	5	6	7	8	9						
	Lateral	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Date of Visual Check :/...../19...

COMMENTS :

A P P E N D I X I

LIST OF ABBREVIATIONS



LIST OF ABBREVIATIONS

ANOVA	:	Analysis of Variance
CRF	:	Visual Contrast Rendition Factor
CTM	:	Eastman Contrast Threshold Visibility Meter
DGF	:	Disability Glare Factor
FVA	:	Factor for Viewing Angle
IERI	:	Illuminating Engineering Research Institute
IES	:	Illuminating Engineering Society
RQOI	:	Recommendations for Quality and Quantity of Illumination
TAF	:	Transitional Adaptation Factor
TII	:	Task Information Index
VARIAC	:	Variable Transformer
VTE	:	Visual Task Evaluator
WHO	:	World Health Organization.

A P P E N D I X J
A SET OF LATIN TEXT PAGES



A SET OF LATIN TEXT PAGES

1. Offset-print on 1st quality paper 6-points size (2 pages)
2. Offset-print on 1st quality paper 8-points size (2 pages)
3. Offset-print on 1st quality paper 11-points size (2 pages)
4. Offset-print on 2nd quality paper 6-points size (2 pages)
5. Offset-print on 2nd quality paper 8-points size (2 pages)
6. Offset-print on 2nd quality paper 11-points size (2 pages)
7. Stencil-print on 2nd quality paper 6-points size (2 pages)
8. Stencil-print on 2nd quality paper 8-points size (2 pages)
9. Stencil-print on 2nd quality paper 11-points size (2 pages)

angustia persistentibus quintus eorum germanus nomine lopichis noster postea proavus extitit inspirante sibi credimus auctore misericordiae captivitatis iugum abicere statuit gentem residue langobardorum meminerat tendere atquere ad libertatis iura sed reppedare stuaeit adgressus fugam adripisset faretram tantum arcum et aliequantulum cibi propter viaticum gerens nesciretque omnino quon pergaret lupus adveniens itineris effectus pergaret frequenter post se respiceret stante subsisteret atque cum pergit praeiret intellexit sibi divinitus datum esse iter quod nescieb ostendaret aliquod dies montium solitudines modo pergentiel panis eidem viatori quem exiguum habuerat omnino defecit quicquam ieiunans fame tabefactus defecisset tetendit arcum suum eundem lupum sumera cibum possit sagitta intrificere voluit praecaves ipse autem recedente eodem lupo nesciens pergeret insperfamisep desperaret sese in terram proiciens obdormivit viditque quendam virum somnis talia sibi verba dicentem surge quid dormissaripen viam hanc partem contra quam pedes tenes illiac tendis quam statim surgens in illam partem quam in somnis audierat pergere coepit ne mora ad habitaculum hominum pervenit erat enim sclavorum habitet illis locis quem cum una mulierem vetula visset statim discessit intellexit fugitivum esse famis penuria laborare ducta autem misericordia potuit nuneta malitiae huius suggestorem atque impelsarem simul pace quasi exploratorem nos rex inquamque romanoam civitatem dominus meus non aut tyrannice invasit liberd tyrannorum liberavit effeminati dominabantur eius quod gravius turpius meretrices dormiebat puto tunc impat decessorum autem nomine oculos impoteras vocantur potentes erantur meretricum sinebant sanctissimorum paparum alii sunt relegati afflictineque cotidianos sumptus elemosiam quirent ad bertus peratoribus decessoribus sanctissimorum apostolorum ecclesias rapinis exvi ductus indignum facinus vindicare sanctam ecclesiam statum orum proprium curavit neglexit vos non oimne finibus terrae surz romaque veniens impios abstulit sanctorum apostolorum vicarie protestatem honorem omnia contdaritit postmodum insurgente vae domnum apostolicum iurisiurandi violatores sacrilegos dominorum suorum terrores raptos secundum decreta romanorum caeterorum cecidit iugulavit supsendit et exilio relegavit facerat impia crudelis tyrannus esse palamest quod berengarius batur sacru leonus atque draconis et despur aquilae volantis insignitum efi ostentaret fortitudinis prudentiae earum rerum efficaciam mot corporis animae constantiam delarans usque inter hanc ferre ultman senectutem aetas perduxit nunquam meos fugere quomodo nunc gregem didici certare scio fugere ignorare valeo si fata non sinunt tunc vivere liceat seltem quod michi dulcissimum cum amicis occumbere exemplum michi paternae virtutis sunt amicorum corpora circumosera maluerunt mori quam impigras amittere inimicis coram loco cedere

blasphemum sacrilego compelluntur aut impia detestantes impert
 caeduntur gladiis bidentium sanctis martyribus sociandi nonesa
 sacrilegis locorum personarum respectus sanctuairis occiduntur
 sacerdotes et levitae coguntur virgines fornicari aut per tormen
 taperire necmatronis aetas maturior suffragatur vaenobis quini
 hanc tam periculosi temporis descendimus miseriam quam in spirod
 praevidens electusa avidrex fidelis deplorat dicens de venorun
 gentasin haereditatem tuam polluerunt templum sanctum et aitemo
 populum humiliaverunt vexaverunt ut quid irasceris in finem velu
 accendetur ignis ira teobi misericordiae tuae verumne est quody
 dicitur obliviscetur misereri deus non continebit in irasua suas
 misericordias recordare acciderit nobis intuere et vide nostrum
 opprobrium vaenobis quidnati sumus videre corruptionem populo
 nostris et contritionem civitatis sanctae et sedere illiecum dant
 rimmanibus inimicorum sancta vosigitur delectissimi armaminiz
 accingimini unusquisque gladioso perfemur potentissime accin
 gimini et estote filii potentis melius est enim mori in bello quam vid
 emala gentis nostrae sanctorum quis zalum legis dei habet nobis
 adiungat subveniamus fratribus nostris dirumpamus vincula aern
 procliamus a nobis iugum ipsorum egredimini vobiscum in uscite
 arma quae caede mutua illicito creentastis in ostenes fidei et eton
 nominis converitare furta in centia rapinas homicidia et caetera
 qualia agunt regnum dei non possidebunt hoc deo beneplacito reda
 obsequio delictorum quibus iracundiam provocastis indulgentia
 provobis obtineant pietatis et deprelio collata sanctor monemus
 igitur exhortamur remissionem peccatorum iniungimus fratribus
 nostris et caelestis regni cohaereditatem emmesenim sumos in vica
 carnifex quies percussores vidisse festinavit ubi ad locum morti
 destinatum venerat occurra divino nimirum admonitus instinctus
 prolectoque saanquem scriptrum tenuerat pedibus eius advolvito
 desiderans cum martyre vel pro quem pro cutere iubeatur ipse potu
 merraretur percuti dum ergo percutore factus esset collegaveri
 et fidei iacens carnifices iusta cunctatio montem cum torbis se
 reverentissimus confessor ascendit qui opore laetus grati ad cen
 quingentis ferre passibus ab arena situsest variles herbarum
 floribus depictus usque vestitus in quo repante praecipue nihilo
 abruptum lateribus lateque deducto in modum aequoris naturae
 conplanat dignum videlicet eum pro insitesabi venustatis iamoli
 reddens quibati martyris cruore dicaretur in huius ergo vertica
 sanctus albanus deari sibia aquam rogavit statimque clussomeatu
 ante pedes eius fons perennis exortus est ut agnoscerent etiam
 torrentum martyri obsequium detulisse neque enim fieri poterat
 ut in ardio montis cacumine martyr aquam in fluvio reliquerat hoc
 ortunam esse non viderat idelicet fluvius inisterio persolutus
 devotione conplatea ofucea relinquens eversus est ad naturam
 decollatus ita mart fortissimus idibeam accepit repromisit perm

angustia persistentibus quintus eorum germanus nomine lopichis
 noster postea proavus extitit inspirante sibi credimus auctore
 misericordiae captivitatis iugum abicere statuit gentem reside
 langobardorum meminerat tendere atquere ad libertatis iura sed
 reppedere stuaeit adgressus fugam adripuisset faretram tantum
 arcum et aliequantulum cibi propter viaticum gerens nesciretque
 omnino quon pergaret lupus adveniens itineris effectus pergaret
 fraquenter post se respiceret stante subsisteret atque cum pergit
 praerit intellexit sibi divinitus datum esse iter quod nesciret
 ostendaret aliquod dies montium solitudines modo pergarentiel
 panis eadem viatori quem exiguum habuerat omnino defecit quicem
 ieiunans fame tabefactus defecisset tetendit arcum suum eundem
 lupum sumera cibum possit sagitta interficere voluit praecaves
 ipse autem recedens eodem lupo nesciens pergeret insperfamise
 desperaret sese in terram proiciens obdormivit viditque quendam
 virum somnis talia sibi verba dicentem surge quid dormissaripen
 viam hanc partem contra quam pedes tenes illac tendis quam statim
 surgens in illam partem quam in somnis audierat pergere coepitne
 mora ad habitaculum hominum pervenit erat enim sclavorum habitet
 illis locis quem cum una mulierem vetula visset statim disset
 intellexit fugitivum esse famis penuria laborare ducta autem
 misericordia potuit nuneta malitiae huius suggestorem atque
 impelsarem simul pace quasi exploratorem nos rexit inquam oqr
 romanoam civitatem dominus meus non aut tyrannice invasit liber
 tyrannorum liberavit effeminati dominabantur eius quod gravius
 turpius meretrices dormiebat puto tunc immopat decessorum aut
 nomine olos impoteras vocantur potentes erant cur meretricum pto
 sinebant sanctissimorum paparum alii sunt relegati afflictinequ
 cotidianos sumptus elemosinam quirent ad bertus peratoribus
 decessoribus sanctissimorum apostolorum ecclesias rapinis exvi
 ductus indignum facinus vindicare sanctam ecclesiam statim om
 proprium curavit neglexit vos non oinmeus finibus terrae surz
 romanque veniens impios abstulit sanctorum apostolorum vicarie
 protestatem honorem omnina contdaritit postmodum insurgente vae
 domnum apostolicum iurisiurandi violatores sacrilegos dominoru
 suorum terrores raptores secundum decreta romanorum caeterorum
 cecidit iugulavit suspensit et exilio relegavit facerat impiosa
 crudelis tyrannus esse palamest quod berengarius batur sacru
 leonus atque draconis et despur aquilae volantis insignitum efi
 ostentaret fortidutineus prudentiac earum rerum efficaciam mot
 corporis animie constantiam delarans usque inter hanc fere ultman
 senectutem aetas perduxit nunquam meos fugere quomodo nunc gore
 didici certare scio fugere ignorare valeosi fata non sinun tlu
 vivere liceat seltem quod michi dulcissimum cum amicis occumbere
 exempli michi paternae virtutis sunt amicorum corpora circanosa
 maluerunt mori quam impigras amittere inimicis coram loco cedere

blasphemant sacrilego compelluntur aut impia detestantes impert
 caeduntur gladiis bidentium sanctis martyribus sociandi nonesa
 sacrilegis locorum personarum respectus sanctuairis occiduntur
 sacerdotes et levitae coguntur virgines fornicari aut per tormen
 taperire nec matronis aetas maturior suffragatur vaenobis qui in
 hanc tam periculosi temporis descendimus miseriam quamin spirod
 praevidens electusa avidrex fidelis deplorat dicens de venorun
 gentsin haereditatem tuam polluerunt templum sanctum et aitemo
 populum humiliaverunt vexaverunt ut quid irascaris in finem velu
 accendetur ignis ira teobi misericordiae tuae verumne est quody
 dicitur obliviscetur misereri deus non continebit in irasua suas
 misericordias recordare acciderit nobis intuere et vide nostrum
 opprobrium vaenobis quid nati sumus videre corruptionem populio
 nostris et contritionem civitatis sanctae et sedere illicum dant
 rimmanibus inimicorum sancta vos igitur delectissimi armaminiz
 accingimini unusquisque gladio suo perfemur potentissime accin
 gimini estote filii potentis melius est enim mori in bello quam vid
 emala gentis nostrae sanctorum quis saluum legis dei habet nobis
 adiungat subveniamus fratribus nostris disrumpamus vincula eorum
 proiciamus anobis iugum ipsorum egredimini vobiscum in uscite
 arma quae caede mutua illicito creantastis in osten fidei et eton
 nominis convertite furta in centia rapinas homicidia et caetera
 qualia agunt regnum dei non possidebunt hoc deo beneplacito reda
 obsequio delictorum quibus iracundiam provocastis indulgentia
 provobis obtineant pietatis et de pretio collata sanctorum monemus
 igitur exhortamur remissionem peccatorum iniungimus fratribus
 nostris et caelestios regni cohaereditibus omnes enim sumos in vicad
 carnifex quicum percussores vidisse festinavit ubi ad locum morti
 destinatum venerat occurra divino nimirum admonitus instinctua
 proiectoque saenquem scriptrum tenuerat pedibus eius advolvito
 desiderans cum martyre vel pro quem pro cutere iubeatur ipse potu
 merraretur percuti dum ergo percutore factus esset collegaveri
 et fidei iacens carnifices iusta cunctatio montem cum torbis se
 reverentissimus confessor ascendit qui opere laetus grati adecen
 quingentis ferre passibus ab arena situsest variis herbarum
 floribus depictus usque vestitus in quo repante praiceps nihilo
 abruptum lateribus lateque deductum in modum aequoris naturae
 conplanat dignum videlicet eum pro insitesabi venustatis iamoli
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angustia persistentibus quintus eorum germanus nomine lopichis noster postea proavus extitit inspirante sibi credimus auctore misericordiae captivitatis iugum abicere statuit gentem residue langobardorum meminerat tendere atque ad libertatis iura se redire reppedere studebat adgressus fugam adripuisset fore tantum arcum et aliquid cibi propter viaticum gerens nesciretque omnino quomodo pergaret lupus adveniens itineris effectus pergaret frequenter post se respiceret stante subsisteret atque cum pergit praeriret intellexit sibi divinitus datum esse iter quod nescire ostendaret aliquod dies montium solitudines modo pergerent iam panem sibi viatori quem exiguum habuerat omnino defecit quicquam ieiunans fame tabefactus defecisset tetendit arcum suum eundem lupum summa cibum possit sagitta interficere voluit praecaves ipse autem recedens eodem lupo nesciens pergeret insperans desperaret sese in terram proiciens obdormivit viditque quendam virum somnis talia sibi verba dicentem surge quid dormis arripere viam hanc partem contra quam pedes tenes illam tendis quam statim surgens in illam partem quam in somnis audierat pergere coepit ne mora ad habitaculum hominum pervenit erat enim sclavorum habitet illis locis quem cum una mulierem vetula visset statim discessit intellexit fugitivum esse famis penuria laborare ducta autem misericordia potuit nunquam malitiae huius suggestorem atque impellerem simul te pace quasi exploratorem nos rex inquam romanorum civitatem dominus meus non aut tyrannice invasit liberum tyrannorum liberavit effeminati dominabantur eius quod gravius turpius meretrices dormiebat puto tunc immo decessorum autem nomine olos impotentes vocantur potentes erant cur meretricum sinebant sanctissimorum paparum alii sunt relegati afflictique quotidianos sumptus elemosinam quarent ad libertatem peratoribus decessoribus sanctissimorum apostolorum ecclesias rapinis ex viductus indignum facinus vindicare sanctam ecclesiam statim ordo proprium curavit neglectus vos non oimne finibus terrarum sursum romanamque veniens impios abstulit sanctorum apostolorum vicarie protestatem honorem omnino contempsit postmodum insurgente vae domnum apostolicum iurisiurandi violatores sacrilegos dominorum suorum terrores raptos secundum decreta romanorum caeterorum cecidit iugulavit suspensit et exilio relegavit faceret impius crudelis tyrannus esse palam est quod berengarius batur sacrum leonem atque draconem et desuper aquilae volantis insignitum efficit ostentaret fortidus prudens earum rerum efficaciam motu corporis animae constantiam delatans usque inter hanc ferre ultimam senectutem aetas perduxit nunquam meos fugere quomodo nunc goro didici certare scio fugere ignorare valeosi fata non sinunt tunc vivere liceat se tunc quod michi dulcissimum cum amicis occumbere exemplum michi paternae virtutis sunt amicorum corpora circum nosra maluerunt mori quam impigras amittere inimicis coram loco cedere

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 gentasin haereditatem tuam polluerunt templum sanctum et aitemo
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 obsequio delictorum quibus iracundiam provocastis indulgentia
 pro vobis obtineant pietatis et de pretio collata sanctorum monemus
 igitur exhortamur remissionem peccatorum iniungimus fratribus
 nostris et caelestios regni cohaereditibus omnem enim sumo in vicad
 carnifex qui eum percussor vidisse festinavit ubi ad locum morti
 destinatum venerat occurra divino nimirum admonitus instinctua
 proiecto saen quem scriptrum tenuerat pedibus eius advolvito
 desiderans cum martyre vel pro quem pro cutere iubeatur ipse potu
 merraretur percuti dum ergo percutore factus esset collegaveri
 et fidei iacens carnifices iusta cunctatio montem cum torbisse
 reverentissimus confessor ascendit qui opere laetus gratia decem
 quingentis ferre passibus ab arena situs est variis herbarum
 floribus depictus usque vestitus in quo repante praecipit nihil
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 proprium curavit neglexitus vosnon oinmeus finibus terrae surz
 romaque veniens impios abstulit sanctorum apostolorum vicarie
 protestatem honorem omnama contdaritit posmodum insurgente vae
 domnum apestolicum iurisiurandi violatores sacrilegos dominoru
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 cecidit iugulavit supsendit etexilio relegavit facerat impiusa
 crudelis tyrannus esseat palamest quod berengarius batur sacru
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 ostentaret fortitudineus prudentiac earum rerum efficaciam mot
 corporis animie costantiam delarans usqueinter hanofere ultman
 senectutem aetas perduxit nunquam meos fugere quomodo nuncgore
 didici certare sciofugere ignororec valeosi fata nonsinun tlu
 vivere liceat seltem quodmichi dulcissimum cumamicis occumbere
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 maluerunt moriquam impigras amittere inimicis coramloco cedera

blasphemant sacrilego compelluntur aut impia detestantes impert
 caeduntur gladiis bidentium sanctis martyribus sociandi nonesa
 sacrilegis locorum personarum respectus sanctuariis occiduntur
 sacerdotes et levitae coguntur virgines fornicari aut per tormen
 taperire necmatronis aetas maturior suffragatur vaenobis quini
 hanc tam periculosi temporis descendimus miseriam quam in spirod
 praevidens electusa avidrex fidelis deplorat dicens de venorun
 gontasin haereditatem tuam polluerunt templum sanctum et ita temo
 populum humiliaverunt vexaverunt ut quid irasceris in finem velu
 accendetur ignis ira teobi misericordiae tuae verumne est quod
 dicitur obliviscetur misereri deus non continebit in irasua suas
 misericordias recordare acciderit nobis intusare et vide nostrum
 opprobrium vaenobis quid nati sumus videre corruptionem populio
 nostris et contritionem civitatis sanctae et sedere illicum dant
 rimmanibus inimicorum sancta vos igitur delectissimi armaminiz
 accingimini unusquisque gladioso perfameur potentissime accin
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 emala gentis nostrae sanctorum quis saluum legis dei habet nobis
 adiungat subveniamus fratribus nostris dirumpamus vincula aern
 proiciamus a nobis iugum ipsorum egredimini vobiscum in uscite
 arma quae caede mutua illicite contentastis in ostenes fidei et ton
 nominis convertite furta incenia rapinas homicidia et caetera
 qualia agunt regnum dei non possidebunt hoc deo beneplacito reda
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 provobis obtineant pietatis et de pretio collata sanctor monemus
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 carnifex quicum percussores vidisse festinavit ubi ad locum morti
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 merraretur percuti dum ergo percutore factus esset collegaveri
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 reverentissimus confessor ascendit qui opore laetus grati ad cen
 quingentis ferre passibus ab arena sitisset variis herbarum
 floribus depictus usque vestitus in quo repante praiceps nihilo
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 sanctus albanus deari sibia aquam rogavit statimque clussomestu
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 devotione conplatea ofucea relinquens eversus est ad naturam
 decollatus ita mart fortissimus idibeam coepit repromisit perm

angustia persistentibus quintus eorum germanus nomine lopichis noster postea proavus extitit inspirante sibi credimus auctore misericordiae captivitatis iugum abicere statuit gentem residue langobardorum meminerat tendere atquere ad libertatis iura studeo reppedere studeo adgressus fugam adripuisset faretram tantum arcum et aliquid cibum propter viaticum gerens nesciretque omnino quomodo pergaret lupus adveniens itineris effectus pergaret frequenter post se respiceret stante subsisteret atque cum pergit praeterire intellexit sibi divinitus datum esse iter quod nescire ostendaret aliquod dies montium solitudines modo pergarentium panem eidem viatori quem exiguum habuerat omnino defecit quicquam ieiunans fame tabefactus defecisset tetendit arcum suum eundem lupum sumere cibum possit sagitta interficere voluit praecaves ipse autem recedente eodem lupo nesciens pergeret insperans desperaret sese in terram proiciens obdormivit viditque quendam virum somnis talia sibi verba dicentem surge quid dormissaris per viam hanc partem contra quam pedes tenes illam tendis quam statim surgens in illam partem quam in somnis audierat pergere coepit ne mora ad habitaculum hominum pervenit erat enim sclavorum habitet illis locis quem cum una mulierem vetula visset statim discessit intellexit fugitivum esse famis penuria laborare ducta autem misericordia potuit nunquam malitiae huius suggestorem atque impersorem simul te pace quasi exploratorem nos rex inquam quae romanoam civitatem dominus meus non aut tyrannice invasit liberum tyrannorum liberavit effeminati dominabantur eius quod gravius turpius meretrices dormiebat puto tunc immo decessorum autem nomine oculos impotentes vocantur potentes erant cur meretricum sinebant sanctissimorum paparum alii sunt relegati afflictiveque cotidianos sumptus elemosinam quae ad libertatem peratoribus decessoribus sanctissimorum apostolorum ecclesias rapinis exvinctus indignum facinus vindicare sanctam ecclesiam statim orationem propriam curavit neglexit vos non omnino finibus terrae super romamque veniens impios abstulit sanctorum apostolorum vicarie protestatem honorem omnino contempsit postmodum insurgente vae domnum apostolicum iurisiurandi violatores sacrilegos dominorum suorum terrores raptos secundum decreta romanorum caeterorum cecidit iugulavit suspendit et exilio relegavit facerat impia crudelis tyrannus esse palam quod berengarius batur sacrum leonem atque draconem et desuper aquilae volantis insignem efficit ostentaret fortitudine prudentiam earum rerum efficaciam motu corporis animae constantiam delirans usque inter hanc ferre ultimum senectutem aetas perduxit nunquam meos fugere quomodo nunc goro didici certare scio fugere ignoro valeosi fata non sinunt tunc vivere liceat seltem quod michi dulcissimum cum amicis occumbere exemplum michi paternae virtutis sunt amicorum corpora circum nosra maluerunt mori quam impigras amittere inimicis coram loco cedere

blasphemant sacrilego compelluntur aut impia detestantes impert
 caeduntur gladiis bidentium sanctis martyribus sociandi nonesa
 sacrilegis locorum personarum respectus sanctuairis occiduntur
 sacerdotes et levitae coguntur virgines fornicari aut per tormen
 taperire nec matronis aetas maturior suffragatur vaenobis quia
 hanc tam periculosa temporis descendimus miseriam quam in spiro
 praevidens electusa avidrex fidelis deplorat dicens de venorun
 gentas in haereditatem tuam polluerunt templum sanctum et aitemo
 populum humiliaverunt vexaverunt ut quid irasceris in finem velu
 accendetur ignis ira teo mihi misericordiae tuae verumne est quod
 dicitur obliviscetur misereri deus non continebit in irasua suas
 misericordias recordare acciderit nobis intueri et vide nostrum
 opprobrium vaenobis quid nati sumus videre corruptionem populi
 nostris contritionem civitatis sanctae et sedere illic cum dant
 in manibus inimicorum sancta vos igitur delectissimi armaminiz
 accingimini unusquisque gladio suo perfemur potentissime accin
 gimini estote filii potentis melius est enim mori in bello quam vid
 emala gentis nostrae sanctorum quis saluum legis dei habet nobis
 adiungat subveniamus fratribus nostris disrumpamus vincula eorum
 proiciamus a nobis iugum ipsorum egredimini vobiscum in uerite
 arma quae caede mutua illicito creantur in hostes fidei et ton
 nominis convertite furta in centia rapinas homicidia et caetera
 qualia agunt regnum dei non possidebunt hoc deo beneplacito red
 obsequio delictorum quibus iracundiam provocastis indulgentia
 pro vobis obtineant pietatis et de pretio collata sanctorum monemus
 igitur exhortamur remissionem peccatorum iniungimus fratribus
 nostris et caelestios regni cohaereditibus omnem enim sumos in vic
 carnifex qui eum percussos vidisse festinavit ubi ad locum morti
 destinatum venerat occurra divino nimirum admonitus instinctua
 proiecitoque saepe quem scribitur tenuerat pedibus eius advolvito
 desiderans cum martyre vel pro quem pro cutere iubeat ipse potu
 merraretur percuti dum ergo percutore factus esset collegaveri
 et fidei iacens carnifices iusta cunctatio montem cum torbisse
 reverentissimus confessor ascendit qui opere laetus grati ad cen
 quingentis ferre passibus ab arena situs est variis herbarum
 floribus depictus usque vestitus in quo repante praecipue nihilo
 abruptum lateribus lateque deductum in modum aequoris naturae
 conplanat dignum videlicet eum pro insitesabi venustatis iamoli
 reddens qui beati martyris cruore dicaretur in huius ergo vertica
 sanctus albanus deari sibi aquam rogavit statimque clussomeatu
 ante pedes eius fons perennis exortus est ut aqua agnoscerent etiam
 torrentum martyri obsequium detulisse neque enim fieri poterat
 ut in ardore montis cacumine martyr aquam in fluvio reliquerat hoc
 ortu non viderat idelicet fluvius inisterio persolutus
 devotione conplatea ofucea relinquens eversus est ad naturam
 decollatus ita mart fortissimus idibeam accepit repromisit perm

angustia persistentibus quintus eorum germanus nomine lopichis
 noster postea proavus exitit inspirante sibi credimus auctore
 misericordiae captivitatis iugum abicere statuit gentem reside
 langobardorum meminerat tendere atquere ad libertatis iura stes
 repperare stuaeit adgressus fugam adripuisset faratram tantum
 arcum et aliequantulum cibi propter viaticum gerens nesciretque
 omnino quon pergerat lupus adveniens itineris effectus pergeret
 fraquenter postae respiceret stante subsisteret atque cum pergit
 praesiret intellexit sibi divinitus datum esse iter quod nescieb
 ostendaret aliquod dies montium solitudines modo pergential
 panis eadem viatori quem exiguum habuerat omnino defacit quicem
 ieiunans fame tabefactus defecisset tetendit arcum suum eundem
 lupum sumens cibum possit sagitta intreficere voluit praecaver
 ipse autem recedens eodem lupo nesciens pergeret inarepfamisep
 desperaret sese in terram proiciens obdormivit viditque quendam
 virum somnis talia sibi verba dicentem surge quid dormissaripen
 viam hanc partem contra quam pedes tenes illiac tendis quam statim
 surgens in illam partem quam in somnis audierat pergere coepit ne
 moras habitaculum hominum pervenit erat enim sclavorum habitet
 illis locis quem cum sumae nullierias vetula visset statim disset
 intellexit fugitivum esset famis penuria laborare ducta autem
 misericordia potuit nuneta malitiae huius suggestorem atque mes
 impelsarem simul ut pace quasi expleptorem nosceat inquam oqr
 romanam civitatem dominus meus non aut tyrannice invasit libere
 tyrannorum liberavit effeminati dominabantur eius quod gravius
 turpis meretrices dormiebat puto tunc impat decessorum aute
 nomine eos impoteras vocantur potentasa erantur meretricum pto
 sinebant sanctissimorum paparum allicunt relegati afflictisqu
 cotidianos sumptus elemosiam quirent adel bertus peratoribus
 decessoribus sanctissimorum apostolorum ecclesias rapinis exvi
 ductus indignus facinus vindicare sanctas ecclesias status orn
 proprius curavit neglexit vos non cinere finibus terras surz
 romaeque veniens impios abetulit sanctorum apostolorum vicaris
 protestatem honorem omnium contdaritit postmodum insurgente vas
 domum apostolicum iurisiurandi violatores sacrilegos dominoru
 suorum tortores raptores secundum decreta romanorum caeterorum
 cecidit iugulavit suspensit et exilio relegavit faceret impiusa
 crudelia tyrannus esset palamest quod barengarius datur sacru
 leonus atque draconis et despur aquilae volantis insignitum efi
 ostentaret fortitudinem prudentiam earum rerum efficaciam mot
 corporis animae constantiam delarans usque inter hanc fere ultiam
 senectutem aetas perduxit nunquam meos fugere quomodo nunqore
 didici certare scio fugere ignorec valeosi fata non sinun tuis
 vivere liceat seltem quod michi dulcissimum cum amicis occumbere
 exempli michi paternae virtutis sunt amicorum corpora circumstera
 maluerunt mori quam impigras amittere iniiciis coram loco cedere

blasphemant sacrilego compelluntur aut impia detestantes impert
 caeduntur gladiis bidentium sanctis martyribus sociandi non esse
 sacrilegia locorum personarum respectus sanctuaris occiduntur
 sacerdotes et levitas coguntur virgines fornicari aut per tormen
 taperire nec matrona aetas maturior suffragatur venobis quin
 hanc tam periculosi temporis descendimus miseriam quam in spire
 praevident electus a vidreus fidelis deplorat dicens de venorum
 gentem haereditatem tuam polluerunt templum sanctum statim
 populum humiliaverunt vexaverunt ut quid irascaris in finem velu
 accendetur ignis ira teo misericordiae tuae verum est quod
 dicitur obliviscetur misereri deus non continebit in iras suas
 misericordiam recordare acciderit nobis intueri et vide nostrum
 opprobrium venobis quid nati sumus videre corruptionem populio
 nostris contritionem civitatis sanctae et sedere illicum dant
 rimantibus inimicorum sancta vos igitur delectissimi armaminis
 accingimini unusquisque gladius perfemur potentissime accin
 gimini estote filii potentis melius est enim mori in bello quam vid
 emala gentis nostrae sanctorum quis saluum legi dei habet nobis
 adiungat subveniamus fratribus nostris dirumpamus vincula eorum
 proiciamus a nobis iugum ipsorum egredimini vobiscum inuenerite
 armae caede mutua illicito croentastis in otes fidei et ton
 nominis convertite furta incensia rapinas homicidia et caetera
 qualia agunt regnum dei non possidebunt hoc deo beneplacito reda
 obsequio delictorum quibus iracundiam provocatis indulgentia
 provobis obtineant pietatis et de pretio collata sanctorum mones
 igitur exhortamur remissionem peccatorum in iungimus fratribus
 nostris et caelestis regni cohaerentibus amorem suum in vobis
 carnifex quies percussores vidisse festinavit ubi locum morti
 destinatum venerat occurrere divino nimirum admonitus instinctus
 proiectorum essentem scriptum tenuerat pedibus eius advolvito
 desiderans cum martyre vel pro quem pro eum iubeat ipse potu
 erraretur percuti dum ergo persecutore factus esset collegaveri
 et fidei iacens carnifices iusta cunctatio montem cum torbisse
 reverentissimus confessor ascendit qui opore laetus gratia deo
 quingentis ferre passibus ab arena sitisset variae herbarum
 floribus depictus usque vestitus in quo repante praiceps nihil
 abruptus lateribus lateque deducto in modum aequoris naturae
 complanatus dignum videlicet e summo insitabili venustatis iamoli
 reddens quibetati martyris cruore dicaretur in huius ergo vertice
 sanctus albanus deari sibi aquam rogavit statimque clussu meatu
 ante pedes eius fons perennis exortus est ut agnoscerent etiam
 torrentum martyri obsequium detulisse neque enim fieri poterat
 ut in ardore montis cacumine martyr aquam in fluvio reliquerat hoc
 fortunam esse non viderat idelicet fluvius inisterio persolutus
 devotione completa ofucea relinquens eversus est ad naturam
 decollatus ita mart fortissimus in dibeum accepit repromisit per

angustia persistentibus quintus eorum germanus nomine lopichis
 noster postea proavus extitit inspirante sibi credimus auctore
 misericordiae captivitatis iugum abicere statuit gentem reside
 langobardorum meminerat tendere atquere ad libertatis iura sed
 reppedere stuaeit adgressus fugam adripuisset faretram tantum
 arcum et aliequantulum cibi propter viaticum gerens nesciretque
 omnino quomodo pergaret lupus adveniens itineris effectus pergaret
 frequenter post se respiceret stante subsisteret atque cum pergit
 praeterit intellexit sibi divinitus datum esse iter quod nescire
 ostendaret aliquod dies montium solitudines modo pergarentiel
 panis eadem viatori quem exiguum habuerat omnino defecit quicquam
 ieiunans fame tabefactus defecisset tetendit arcum suum eundem
 lupum summa cibum possit sagitta interficere voluit praecaves
 ipse autem recedente eodem lupo nesciens pergeret insperans
 desperaret sese in terram proiciens obdormivit viditque quendam
 virum somnis talia sibi verba dicentem surge quid dormis arripen
 viam hanc partem contra quam pedes tenes illam tendis quam statim
 surgens in illam partem quam in somnis audierat pergere coepit
 mora ad habitaculum hominum pervenit erat enim sclavorum habitet
 illis locis quem cum una mulierem vetula visset statim disset
 intellexit fugitivum esse famis penuria laborare ducta autem
 misericordia potuit nuda malitiae huius suggestorem atque imes
 impellere simul pace quasi exprobatorem nos rexit inquam oqr
 romanoam civitatem dominus meus non aut tyrannice invasit liber
 tyrannorum liberavit effeminati dominabantur eius quod gravius
 turpius meretrices dormiebat puto tunc immo pat decessorum aut
 nomine olos impoteras vocantur potentes erant cur meretricum pto
 sinebant sanctissimorum paparum alii sunt relegati afflictine qu
 cotidianos sumptus elemosinam quirent ad bertus peratoribus
 decessoribus sanctissimorum apostolorum ecclesias rapinis exvi
 ductus indignum facinus vindicare sanctam ecclesiam statum oim
 proprium curavit neglexit vos non oim eius finibus terrae surz
 romanque veniens impios abstulit sanctorum apostolorum vicarie
 protestatem honorem omnia contdaritit postmodum insurgente vae
 domnum apostolicum iurisiurandi violatores sacrilegos dominoru
 suorum terrores raptos secundum decreta romanorum caeterorum
 cecidit iugulavit suspendit et exilio relegavit facerat impius
 crudelis tyrannus esse palam est quod berengarius batur sacru
 leonus atque draconis et despur aquilae volantis insignitum efi
 ostentaret fortitudine prudentiam earum rerum efficaciam mot
 corporis animae constantiam delarans usque inter hanc ferre ultma
 senectutem aetas perduxit nunquam meos fugere quomodo nunc gore
 didici certare scio fugere ignoro rec valeosi fata non sinun tlie
 vivere liceat seltem quod michi dulcissimum cum amicis occumbere
 exempli michi paternae virtutis sunt amicorum corpora circansra
 maluerunt mori quam impigras amittere inimicis coram loco cedere

blasphemant sacrilego compelluntur aut impia detestantes impert
 caeduntur gladiis bidentium sanctis martyribus sociandi nonesa
 sacrilegis locorum personarum respectus sanctuairis occiduntur
 sacerdotes et levitae coguntur virgines fornicari aut per tormen
 taperire nec matronis aetas maturior suffragatur vaenobis quini
 hanc tam periculosi temporis descendimus miseriam quam in spirod
 praevideus electusa avidyrex fidelis deplorat dicens de venorun
 gentasin haereditatem tuam polluerunt templum sanctum et aitemo
 populum humiliaverunt vexaverunt ut quid irasceris in finem velu
 accendetur ignis ira teobi misericordiae tuae verumne est quod
 dicitur obliviscetur misereri deus non continebit in irasua suas
 misericordias recordare acciderit nobis intueri et vide nostrum
 opprobrium vaenobis quid nati sumus videre corruptionem populio
 nostris et contritionem civitatis sanctae et sedere illicum dant
 rinmanibus inimicorum sancta vos igitur delectissimi armaminiz
 accingimini unusquisque gladio suo perfemur potentissime accin
 gimini et estote filii potentis melius est enim mori in bello quam vid
 emala gentis nostrae sanctorum quis saluum legis dei habet nobis
 adiungat subveniamus fratribus nostris dirumpamus vincula eorum
 proiciamus a nobis iugum ipsorum egredimini vobiscum in uscite
 arma quae caede mutua illicito creentastis in ostenes fidei et ton
 nominis convertite furta incendia rapinas homicidia et caetera
 qualia agunt regnum dei non possidebunt hoc deo beneplacito reda
 obsequio delictorum quibus iracundiam provocastis indulgentia
 provobis obtineant pietatis et de pretio collata sanctorum monemus
 igitur exhortamur remissionem peccatorum iniungimus fratribus
 nostris et caelestios regni cohaereditibus omnes enim sumus in via
 carnifex quaeum percussores vidisse festinavit ubi ad locum morti
 destinatum venerat occurra divino nimirum admonitus instinctua
 proiectoque saenquem scriptrum tenuerat pedibus eius advolvito
 desiderans cum martyre vel pro quem pro cutere iubeatur ipse potu
 merraretur percussus dum ergo percutore factus esset collegaveri
 et fidei iacens ferarum carnifices iusta cunctatio montem cum torbis
 reverentissimus confessor ascendit qui opore laetus grati ad cen
 quingentis ferre passibus ab arena situs est variis herbarum
 floribus depictus usque vestitus in quo repante praecipue nihilo
 abruptum lateribus lateque deductum in modum aequoris naturae
 conplanat dignum videlicet eum pro insitesabi venustatis iamoli
 reddens quibus beati martyris cruore dicaretur in huius ergo vertica
 sanctus albanus deari sibi aquam rogavit statimque clussomeatu
 ante pedes eius fons perennis exortus est ut aqua agnoscerent etiam
 torrentum martyri obsequium detulisse neque enim fieri poterat
 ut in ardio montis cacumine martyr aquam influvio reliquerat hoc
 fortunam esse non viderat idelicet fluvius inisterio persolutus
 devotione conplatea ofucea relinquens eversus est ad naturam
 decollatus ita mart fortissimus idibeam cepit repromisit perm

angustia persistentibus quintus eorum germanus nomine lopichis
 noster postea proavus extitit inspirante sibi credimus auctore
 misericordiae captivitatis iugum abicere statuit gentem reside
 langobardorum meminerat tendere atquere ad libertatis iura sed
 reppedare stuaeit adgressus fugam adripuisset faretram tantum
 arcum et aliequantulum cibi propter viaticum gerens nesciretque
 omnino quon pergaret lupo adveniens itineris effectus pergaret
 frequenter post se respiceret stante subsisteret atque cum pergit
 praeriret intellexit sibi divinitus datum esse iter quod nesciret
 ostendaret aliquod dies montium solitudines modo pergarentiel
 panis eidem viatori quem exiguum habuerat omnino defacit quicem
 ieiunans fame tabefactus defecisset tetendit arcum suum eundem
 lupo sumera cibum possit sagitta interficere voluit praecaves
 ipse autem recedente eodem lupo nesciens pergeret insperans
 desperaret sese in terram proiciens obdormivit viditque quandam
 virum somnis talia sibi verba dicentem surge quid dormissaris
 viam hanc partem contra quam pedes tenes illuc tendis quam statim
 surgens in illam partem quam in somnis audierat pergere coepit
 mora ad habitaculum hominum pervenit erat enim sclavorum habitet
 illis locis quem cum una mulierem vetula visset statim disset
 intellexit fugitivum esse famis penuria laborare ducta autem
 misericordia potuit nunta malitiae huius suggestorem atque
 impersarem simul te pace quasi exploratorem nos rex inquam
 romanoam civitatem dominus meus non aut tyrannice invasit liber
 tyrannorum liberavit effeminati dominabantur eius quod gravius
 turpius meretrices dormiebat puto tunc impotentes decessorum
 autem nomine oculos impotentes vocantur potentes erant cur meretricum
 sinebant sanctissimorum paparum alii sunt relegati afflictique
 cotidianos sumptus elemosinam quarent ad libertatem peratoribus
 decessoribus sanctissimorum apostolorum ecclesias rapinis ex
 ductus indignum facinus vindicare sanctam ecclesiam statim
 proprium curavit neglexit vos non oimne finibus terrae sur
 romamque veniens impios abstulit sanctorum apostolorum vicarie
 protestatem honorem omnino contempsit postmodum insurgente
 domno apostolicum iurisdictioni violatores sacrilegos dominorum
 suorum terrores raptos secundum decreta romanorum caeterorum
 cecidit iugulavit suspendit et exilio relegavit faceret impia
 crudelis tyrannus esse palam est quod berengarius batur sacro
 leonus atque draconis et despur aquilae volantis insignitum
 ostentaret fortitudine prudentiam earum rerum efficaciam mot
 corporis animae constantiam delirans usque inter hanc fere ult
 man senectutem aetas perduxit nunquam meos fugere quomodo
 nunc goro didici certare scio fugere ignorare valeosi fata non
 sinum tunc vivere liceat seltem quod michi dulcissimum cum
 amicis occumbere exemplum michi paternae virtutis sunt amicorum
 corpora circum nos mala maluerunt mori quam impigras amittere
 inimicis coram loco cedere

blasphemant sacrilego compelluntur aut impia detestantes impert
 caeduntur gladiis bidentium sanctis martyribus sociandi nonesa
 sacrilegis locorum personarum respectus sanctuairis occiduntur
 sacerdotes et levitae coguntur virgines fornicari aut per tormen
 taperire necmatronis aetas maturior suffragatur vaenobis quin
 hanc tam periculosi temporis descendimus miseriam quamin spirod
 praevidens electusa avidrex fidelis deplorat dicens de venorun
 gentasin haereditatem tuam polluerunt templum sanctum et aitemo
 populum humiliaverunt vexaverunt ut quid irasceris in finem velu
 accendetur ignis ira teobi misericordiae tuae verumne est quody
 dicitur obliviscetur misereri deus non continebit in irasua suas
 misericordias recordare acciderit nobis intueri et vide nostrum
 opprobrium vaenobis quid nati sumus videre corruptionem populo
 nostris et contritionem civitatis sanctae et sedere illicum dant
 rinmanibus inimicorum sancta vos igitur delectissimi armaminiz
 accingimini unusquisque gladius suo perfemur potentissime accin
 gimini et estote filii potentis melius est enim mori in bello quam vid
 emala gentis nostrae sanctorum quis saluum legis dei habet nobis
 adiungat subveniamus fratribus nostris disrumpamus vincula eorum
 proliciamus a nobis iugum ipsorum egredimini vobiscum in uscite
 arma quae caede mutua illicito croentastis in ostenes fidei et eton
 nominis convertitare furta in centia rapinas homicidia et caetera
 qualia agunt regnum deinum possidebunt hoc deo beneplacito reda
 obsequia delictorum quibus iracundiam provocastis indulgentia
 provobis obtineant pietatis et de preterito collata sanctorum monemus
 igitur exhortamur remissionem peccatorum iniungimus fratribus
 nostris et caelestis regni cohaerentibus omnem in sumos in vicad
 carnifex quiescens percussores vidisse festinavit ubi ad locum morti
 destinatum venerat occurra divino nimirum admonitus instinctua
 proiectoque saenquam scriptrum tenuerat pedibus eius advolvito
 desiderans cum martyre vel pro quem pro cutere iubeator ipse potu
 merraretur percuti dum ergo percutore factus esset collegaveri
 et fidei iacens fer carnifices iusta cunctatio montem cum torbisse
 reverentissimus confessor ascendit qui opere laetus grati ad decem
 quingentis ferre passibus ab arena situs est variis herbarum
 floribus depictus usque vestitus in quo repante praecipue nihilo
 abruptum lateribus lateque deductum in modum aequoris naturae
 conplanat dignum videlicet eum pro insitesabi venustatis iamoli
 reddens quibus beati martyris cruore dicaretur in huius ergo vertica
 sanctus albanus de ari sibi aquam rogavit statimque clussomeatu
 ante pedes eius fons perennis exortus est ut aqua agnoscerent etiam
 torrentum martyri obsequium detulisse neque enim fieri poterat
 ut in arido montis cacumine martyr aquam in fluvio reliquerat hoc
 ortum esse non viderat id est fluvius inisterio persolutus
 devotione conplatea ofucea relinquens eversus est ad naturam
 decollatus ita mart fortissimus id est eum accepit repromisit perm