

I LIGHTING

1 GENERAL

- 1.1 The work of this section includes the provision of all design, labour, materials, equipment and services required to fabricate and install lighting as required for a complete project. The work includes, but is not necessarily limited to, the items referenced herein:
- 1.1.1 General Lighting Systems
 - 1.1.2 Task Lighting Systems
 - 1.1.3 Specialty Lighting
 - 1.1.4 Emergency Lighting
 - 1.1.5 Exit Lighting
- 1.2 Provide suitable, lighting system to meet functional criteria of the facility ensuring adequate light levels are maintained and energy consumption is minimized.
- 1.3 Standards:
- 1.3.1 IES - Illuminating Engineering Society – Latest edition
 - 1.3.2 Lighting for Educational Facilities RP-3
- 1.4 Submittals:
- 1.4.1 Submit shop drawings.
 - 1.4.2 Submit lighting calculations for each room, computer simulated in an approved IES format.
- 1.5 Operations and Maintenance Manuals:
- 1.5.1 Provide maintenance details for inclusion in Operations and Maintenance Manual.
 - 1.5.2 Provide list of fixtures.
 - 1.5.3 Provide list of ballast and lamps.
 - 1.5.4 Provide list of spare parts and suppliers.
- 1.6 Commissioning:
- 1.6.1 Equipment supplied shall be tested and put into operation complete with all control systems.

2 DESIGN

- 2.1 Lighting

2.1.1 Lighting systems are to be designed to meet the functional criteria of each area and specific lighting task.

2.2 Classroom

2.2.1 The lighting system should be equally flexible and responsive. Luminaires should be arranged so that desk locations will not be dictated by the lighting.

2.2.2 Classroom luminaires can be arranged in a variety of patterns; however, special consideration shall be given to the orientation of the luminaires with regard to the following factors:

2.2.2.1 Predictable or unpredictable position and orientation of desks

2.2.2.2 Location of whiteboard

2.2.2.3 Location and proximity of windows

2.2.2.4 Ceiling height

2.2.2.5 Photometric characteristic of luminaires

2.2.2.6 Flexibility of the space for other functions.

2.3 Lighting for Audio-visual Presentations

2.3.1 Television, slides and film are used extensively in classrooms. For effective viewing it is necessary to reduce or to turn off the general overhead lighting. The room should not be completely darkened. Multi-level switching shall be used.

2.4 Spaces for Visual Display Terminals

2.4.1 Visual display terminals (VDTs) used in classrooms have special lighting needs. The lighting design shall meet the requirements of RP-1, published by the Illuminating Engineering Society.

2.4.2 The lighting design in spaces with VDT shall be able to control direct and reflected glare and limit luminance in both the immediate task surround and within the dynamic field of view. The lighting design process for areas containing VDT screens shall begin with an analysis of all visual tasks to be performed. It is important to determine how the VDT screen is used, what type of visual image it displays, and the angular relationship between the user, the VDT screen and the paper task. In order to achieve a comfortable balance of luminance within the VDT environment and limit the effects of transient adaptation and disability glare, recommended luminaire ratios should not be exceeded.

2.4.2.1 Spaces with limited VDT use

2.4.2.1.1 In spaces where the use of VDT is limited, more attention shall be paid to the paper task. The recommended luminance ratio between the paper task and adjacent VDT screens is 3:1.

2.4.2.2 Spaces with constant VDT use

2.4.2.2.1 VDT visual tasks differ from conventional paper tasks. Whereas paper tasks are typically performed looking downward at a horizontal task, a typical VDT visual task is performed in a “head-up” position. Because of this, a large area of the ceiling may be in the field of view. For this reason, it is important to limit luminance on the ceiling plane in order to prevent discomfort glare or adaptation problems.

2.4.2.2.2 Colour contrasts can also often add to visual clarity, depth perception, and orientation without major luminance variations. The reflectance values of all fabrics and finishes will affect luminance values and may impact perceived brightness as much as illuminance. Therefore, their selection and placement are critical to the lighting design.

2.4.2.2.3 The recommended luminance ratio for immediate background surround is 3:1 for dark (low reflectance) backgrounds and 1:3 for light (high reflectance) backgrounds. For remote background, the recommended luminance ratio is 10:1 for dark backgrounds, and 1:10 for lighting backgrounds.

2.4.2.2.4 The light remote backgrounds would include light sources such as the luminaires and windows visible from the workstation.

2.5 Classrooms

2.5.1 A classroom should have a general lighting system which is flexible enough to provide at least three illuminances, the higher level for note-taking and a subdued one for demonstrations and an intermediate level. A direct/indirect lighting system to be used.

2.5.2 If a demonstration table is to be used, directional downlights should be located at a 40-60° angle above the horizontal in relation to the location of the lecturer.

2.5.3 This minimizes glare and provides good lighting for the speaker’s face. Such lighting can be arranged to allow use of an audio-visual screen at the same time that the lecturer is speaking.

2.5.4 Whiteboard lighting shall be provided to evenly illuminate the whiteboard and shall be controlled by an individual switch.

2.6 Lighting in office space application is to be generally fluorescent, deep cell parabolic

units where T-bar, drywall or other suspended ceiling systems are installed.

2.7 Luminaires are to be provided electronic ballast rated for the utilized supply voltage. HID or fluorescent systems are to be 347V.

2.8 Low Voltage Lighting Controls

2.8.1 All lighting systems, except those required for emergency or exit lighting, shall be provided with manual, and automatic controls. Each space enclosed by walls or ceiling-high partitions, shall be required to have one control point and, in addition, one control point for each task location or one control point for each group of task locations within an area of 450 square feet or less.

2.8.2 Lighting control requirements for spaces which must be used as a whole may be controlled by a lesser number of controls but not less than one control point per each 1500 W of connected lighting power or a total of three control points, whichever is greater. Classrooms shall be provided with occupancy sensor as a control point, manual toggle switches for multi-level lighting as well as sensor for daylight harvesting. All lighting controls shall be located so as to be readily accessible to personnel occupying the space.

2.8.3 For other areas such as corridors or areas with dedicated mechanical systems, the lighting shall be monitored and controlled by the BAS system.

2.8.4 The low voltage lighting control system shall be a standalone system and interfaced with the BAS system. The system shall include transformer, relays and controller in the ceiling space of the area being controlled. Devices such as switches, motion sensors, daylight harvesting sensors shall be connected directly to the relay/controller in the ceiling space.

2.9 All fixtures and components are to bear CSA approved labels, where this is not possible local hydro authority approval shall be obtained.

2.10 Lighting design levels and layouts are to be determined using recognized methods room cavity, point to point or specialty software. All calculations or print outs are to be submitted for record.

2.11 Power Loading – Lighting

2.11.1 Power loading shall be measured as watts per square metre (W/m^2) of usable space. Power shall be calculated as total wattage for lamps, ballasts and control circuitry at a specified voltage.

2.11.2 Typical target power budget values are shown below:

Table 1 - Unit Power-Density for Typical Common Areas - Lighting

Description	W/m^2
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Lecture hall/classrooms	11
Library:	
o audio-visual	11
o stack area (stack lighting)	14
o reading area	12
General office area:	
o no partitions	10
o with partitions <1.4 m	12
o with partitions <1.8 m	12
Computer/Word Processing	11
Laboratories	15
Lobby	7.5
Atria	7.5
Reception Area	10
Auditorium	12
Elevator Lobby	7.5
Conference meeting rooms	12
Electrical/Mechanical rooms	7
Washrooms	7.5
Locker Room>Showers	8
Stairs/corridors	7

2.11.3 These power loadings shall not be exceeded unless the task or College requirements create a need for additional power which can be justified on the basis of work and space requirements and the health and/or safety of the building users.

2.12 Illumination Levels

2.12.1 The following are illumination levels for various interior spaces expressed as minimum acceptable values of average maintained horizontal lux level over the working plane of each workstation, at floor level for support spaces.

Description of Task Illumination (lx)

Classrooms	400-600
Shops	750
Lecture Rooms	300-600
High Contrast Visual Task	600
Low Contrast Visual Task	1,000
Compartmentalized Workstations	300
VDT use	300-500
Filing Work	300
Reception areas, interview rooms	300
Circulation areas immediate to task areas	300-400
Public spaces, lounges	200-300
Conference, training rooms	300-600
Laboratories	750
Service Rooms	300-500
Corridors	100-200
Washrooms	200
Stairways	100

2.13 Exit and Emergency Lighting

2.13.1 Exit and emergency lighting shall comply to the Ontario Building Code, all municipal bylaws, and all authorities having jurisdiction.

2.14 Minimum Lighting Requirements

2.14.1 Every exit, public corridor, corridor providing access to exit for the public, corridor serving classrooms, electrical equipment room, transformer vault and hoistway pit shall be equipped to provide illumination to an average level of not less than 50 lux at floor level and at all points such as angles and intersections at changes of level where there are stairs or ramps.

2.15 Emergency Lighting

2.15.1 Emergency lighting shall be provided to average levels of not less than 10lx at floor level in

2.15.1.1 Exits

2.15.1.2 principal routes providing access to exit in an open floor area

- 2.15.1.3 corridors used by the public
 - 2.15.1.4 corridors serving classrooms
 - 2.15.1.5 underground *walkways*
 - 2.15.1.6 public corridors
 - 2.15.1.7 auditoriums having a capacity greater than 60.
 - 2.15.1.8 washrooms, showers
- 2.16 Exit Signage
- 2.16.1 Every exit door other than the main entrance to a room or building shall have an exit sign placed over or adjacent to the door when the exit serves a room or floor area that has a fire escape as part of a required means of egress.
 - 2.16.2 Every exit sign shall
 - 2.16.2.1 be visible from the exit approach
 - 2.16.2.2 have the word EXIT displayed in plain legible letters, and
 - 2.16.2.3 be designed to be illuminated continuously while the building is occupied.
 - 2.16.3 Illumination of an exit sign shall be provided from an electrical circuit. That circuit shall
 - 2.16.3.1 serve no equipment other than emergency equipment, and
 - 2.16.3.2 be connected to an emergency power supply.
 - 2.16.4 Signs shall be provided to indicate the direction of egress in public corridors and passageways, and shall have the word EXIT with a suitable arrow or pointer indicating the direction of egress.
- 2.17 Emergency Power for Lighting
- 2.17.1 An emergency power supply shall be provided to maintain the emergency lighting from a power source such as batteries or generators that will continue to supply power in the event that the regular power supply to the *building* is interrupted and be so designed and installed that upon failure of the regular power it will assume the electrical load automatically for a period of 30 minutes.
 - 2.17.2 Where self-contained emergency lighting units are used, they shall conform to CSA C22.2 No. 141, "Unit Equipment for Emergency Lighting". Battery units to be sized to provide 30 minutes supply for connected load plus 50 W spare capacity.
- 2.18 Services to lighting fixtures are to be RW90 cables in EMT conduit to junction boxes

located adjacent to the fixtures with final connections in BX cable, the length of BX shall not exceed 2 m.

3 MATERIALS

3.1 General Requirements

- 3.1.1 Provide lighting fixtures of sizes, types and ratings as required, complete with, but not necessarily limited to, housings, lamps, lamp holders, reflectors, ballasts, starters, wiring and batteries and battery charging devices.
 - 3.1.1.1 Form fixture sheet metal housings to prevent warping and sagging. Return or clean all edges free of all burrs or sharp spots. Provide fixtures free from light leaks after installation.
 - 3.1.1.2 Hinged door closure frames shall operate smoothly without binding. Fabricate frames to allow lamp installation/removal without tools. Hinge mechanism shall be designed to preclude accidental falling of hinged door closure frames during relamping operations and while secured in operating position.
 - 3.1.1.3 Interior light reflecting surfaces shall have reflectance of not less than 85 percent for white surfaces, 83 percent for specular surfaces and 75 percent for specular diffusing surfaces.
 - 3.1.1.4 Provide manufacturer's standard finish applied over corrosion-resistant primer, free of streaks, runs, holidays, stains, blisters, or similar defects. Remove any fixtures showing evidence of rust at time of final inspection.
 - 3.1.1.5 Light transmitting components shall be fabricated of 100 percent virgin acrylic plastic or water white, annealed, crystal glass. Minimum average thickness of lenses for fluorescent fixtures shall be 3.2 mm. Fabricate frames to allow for expansion of lens without distortion or cracking. For plastic lenses, diffusers, and covers, provide high resistance to yellowing due to UV radiation.
 - 3.1.1.6 Provide each fixture with lamps as required. Where lamps are not indicated, provide lamps as recommended by manufacturer.
 - 3.1.1.7 For locations with severe environmental conditions such as damp, high temperature, or flammable vapours provide fixtures specifically labelled and listed for the particular conditions to be encountered.
 - 3.1.1.8 Furnish and install lighting fixtures as required. Fixtures shall be completely wired and lamps installed and shall be in perfect operating condition at the time of completion.
 - 3.1.1.9 Lighting fixtures shall be of rigid construction, dimensionally stable, and shall be assembled with secure fastenings. Ferrous parts shall be

protected from corrosion by plating or shall be finished with high reflectance enamel with non-yellowing binder and high pigment to binder ratio, with matte finish. Ferrous parts shall be prepared for finish by industry standard finishing process.

- 3.1.1.10 Recessed lighting fixtures, indirect lighting system and lighting track systems shall be suspended from structural members. Fixture locations shall be coordinated with ceiling patterns. Provide structural steel if necessary to properly support the fixtures.
- 3.1.1.11 Fixture wiring shall be suitable for the temperature rating of the fixture. Where a junction box is required to change from branch circuit to fixture wiring, use approved feed through pre-wired fixture wiring, install a separate junction box. The junction box shall be fully accessible after installation of covering materials. Where flexible conduit or portable cord is used, a grounding jumper shall be installed; all fixtures shall be grounded.
- 3.1.1.12 All recessed, pendant and surface mounted lighting fixtures, shall be CSA approved for thru-wiring and shall be furnished complete with all required integral wiring and all required flexible conditions, pigtails and related accessories necessary for suitable operation and installation.
- 3.1.1.13 All materials, accessories, and other related fixture parts shall be new and free from defects which, in any manner, may impair their character, appearance, strength, durability and function, and be effectively protected from any damage or injury from the time of fabrication to the time of delivery and until final acceptance of the work.
- 3.1.1.14 Sheet metal work: all sheet metal work shall be free from tool marks and dents, and shall have accurate angles bent as sharp as compatible with the gauges of the required metal. All intersections and joints shall be formed true of adequate strength and structural rigidity to prevent any distortion after assembly.
- 3.1.1.15 Housings shall be so constructed that all electrical components are easily accessible and replaceable without removing fixtures from their mountings, or disassembly of adjacent construction.
- 3.1.1.16 Castings: all aluminum, iron or composite castings shall be exact replicas of the approved patterns and shall be free of sand pits, blemishes, scales and rust, and shall be smoothly furnished. Tolerance shall be provided for any shrinkage of the metal castings in order that the finished castings will accurately fit in their designated locations.
- 3.1.1.17 Mounting frames and rings: if ceiling system requires, each recessed and semi-recessed fixture shall be furnished with a mounting frame or ring

compatible with the ceiling in which they are to be installed. The frames and rings shall be one piece or constructed with electrically welded butt joints and of sufficient size and strength to sustain the weight of the fixture.

- 3.1.1.18 Yokes, brackets and supplementary supporting members needed to mount lighting fixtures to carrier channels, suitable ceiling members or other structure shall be furnished and installed by the Design Builder.
- 3.1.1.19 For steel and aluminum fixtures all screws, bolts, nuts and other fastening and latching hardware shall be cadmium or equivalent plated. For stainless steel fixtures, all hardware shall be stainless steel. For bronze fixtures, all hardware shall be stainless steel or bronze.
- 3.1.1.20 Extruded aluminum frame and trim shall be rigid and manufactured from quality aluminum without blemish or warping in the installed product. Mitre cuts shall be accurate. Joints shall be flush and without burrs. Cuts shall maintain alignment with the light fixture located in its final position.
- 3.1.1.21 Fixtures shall be constructed to allow proper ventilation of lamps and ballast to prevent degraded lamp light output, premature component degradation, or hazardous conditions.
- 3.1.1.22 Recessed and Flush-Mounted Fixtures: Provide type that can be relamped from the bottom. Trim for the exposed surface of flush –mounted fixtures shall be as required. Provide trims, mountings, supports and adapters for type of ceiling in which mounted. Fixtures recessed in a plaster ceiling shall have plaster frames.
- 3.1.1.23 Provide wire guards for all fixtures located in service rooms or subject to mechanical injury.
- 3.1.1.24 Suspended Fixtures:
 - 3.1.1.24.1 Provide hangers or aircraft cables capable of supporting twice the combined weight of the adjoining fixtures plus 100 kg.
 - 3.1.1.24.2 Support: Brace pendants 1200 mm or longer to limit swinging. Provide single-unit suspended fluorescent fixtures with twin-stem hangers.
 - 3.1.1.24.3 Multiple-Unit or Continuous Row Fixtures: Provide multiple-unit or continuous row fluorescent fixtures with tubing or stem for wiring at one point and a tubing or rod suspension for each unit length of chassis, including one at each end. Provide rods with minimum 5 mm diameter.

3.2 Fluorescent Ballasts

- 3.2.1 Provide fluorescent ballasts conforming to CSA standards and to UL 935,

“Fluorescent-Lamp Ballasts”, ANSI C82.1, “Ballasts for Fluorescent Lamps – Specifications”. Provide fixtures labelled by CBM and certified by Electrical Testing Laboratories (ETL). Ballasts shall be high power factor type, unless indicated otherwise, designed to operate on the voltage system to which they are connected. Ballasts shall be Class P with sound rating “A” unless otherwise noted. Fixtures and ballasts shall be designed and constructed to limit the ballast case temperature to 90°C when installed in an ambient temperature of 40°C.

- 3.2.1.1 Ballasts shall be designed for input voltage of circuits to which they are connected. Submit for each type of fixture used in the project certification that each type of fixture being used in the project has been tested, equipped and mounted as it is to be finally installed in the project and found to operate satisfactorily and as specified including complete absence of cyclical operation of the ballast protector for the installation method, mounting, location, and environmental conditions which the fixture is to be used in this project. Maintain the conditions required by the manufacturer for proper operation throughout the construction period.
- 3.2.1.2 Low Temperature Ballasts: provide fluorescent ballasts having a minimum starting temperature of –20°C in fixtures located where ambient temperature may fall below 10°C.
- 3.2.1.3 Energy saving magnetic ballasts shall not be used.
- 3.2.1.4 Solid-state Electronic Ballasts: provide energy efficient solid-state electronic ballasts. The ballasts shall maintain lamp filament heating after the lamps are started to assure optimum lamp life. The ballasts shall be designed to operate at an input frequency of 60 Hz and shall invert the low frequency to a high frequency (20 kHz – 60 kHz) and apply this to the lamps which shall operate without visible flicker. Ballast shall be designed to exclusively operate specified lamp types.
 - 3.2.1.4.1 Ballasts shall be non PCB and RFI limited.
 - 3.2.1.4.2 Ballasts shall have high power factor/minimum 90 percent, UL listed for Class P, sound rated A, type I outdoor.
 - 3.2.1.4.3 Ballast shall be high frequency (20 kHz or greater) and operate without visually detectable flicker (stroboscopic effect).
 - 3.2.1.4.4 Ballast case operating temperature shall not exceed 35°C temperature rise.
 - 3.2.1.4.5 Ballast casing shall have a thermo-setting and 100 percent filler to serve as a conformal coating and protective insulation against both internal and external damage.

- 3.2.1.4.6 Ballast shall have a 3-year written warranty from date of installation against mechanical or electrical defects under normal conditions of use.
- 3.2.1.4.7 Electronic ballast shall have a crest factor of no more than 1.7.
- 3.2.1.4.8 Electronic ballast operation shall insure that lamp lumen output is no less than 97% of lamp manufacturer's printed lumen output utilizing standard core and coil ballasts.
- 3.2.1.4.9 Harmonic Distortion: Ballast shall not generate total harmonics (THD) in excess of 10%. Test shall demonstrate performance using specified number and type of lamps.
- 3.2.1.4.10 Ballast shall be short circuit protected.
- 3.2.1.4.11 Line Transient Protection: ballast shall be designed to withstand line transients as defined in IEEE Publication 587, Category A.
- 3.2.1.4.12 All 265 mA T-8 electronic ballasts shall be rapid start.
- 3.2.1.4.13 Reduced current ballasts are not acceptable.

3.3 Lamps

- 3.3.1 Unless otherwise indicated, all lamps specified shall be manufactured by G.E., Osram Sylvania or Philips.
- 3.3.2 All lamps where applicable shall comply with ANSI C78 Series standards.
- 3.3.3 Fluorescent: fluorescent lamps shall be of wattage, voltage and lumen output as required. Lumen output at 33% rated life shall not be less than 80% of initial output. Design Builder shall replace any lamps failing during the first two hundred (200) days of burning after final acceptance.
 - 3.3.3.1 Fluorescent: T-5 HO lamps:
 - 3.3.3.1.1 Unless otherwise indicated or authorized, all linear fluorescent lamps for use on this project shall be 1220 mm, 4100K triphosphor type as manufactured by G.E., Osram Sylvania, Philips, with a minimum CRI of 85. Rated average life shall be not less than 20,000 hours. Lamps shall be operated on solid-state electronic ballast.
 - 3.3.3.2 Fluorescent: Compact
 - 3.3.3.2.1 Unless otherwise indicated or authorized all compact fluorescents for use on this project shall be the triple tube 4100K with a minimum CRI of 80 by G.E., Osram Sylvania, Philips. Rated average life shall be not less than 10,000 hours.

- 3.3.4 Incandescent and tungsten Halogen: Incandescent and tungsten halogen lamps shall be of wattage required operating at 120 volts with a rated average life minimum of 2000 hours unless otherwise noted. Lumen output at 70% of rated life shall not be less than 80% of initial output. Design Builder shall after final acceptance replace any lamps failing during the first sixty (60) days of operation.
- 3.3.5 High Intensity Discharge: H.I.D. lamps shall be of wattage required. 3200K with minimum CRI of 70 as manufactured by G.E., Osram Sylvania, Philips. Rated average life shall be not less than 7500 hours for PAR type and 10,000 hours for ED and BD types.

3.4 Reflectors

- 3.4.1 Reflectors, cones or baffles shall be absolutely free of spinning lines, stains, ripples or any marks or indentations caused by riveting to other assembly techniques. No rivets, springs or other hardware shall be visible after installation.
- 3.4.2 Downlight reflectors shall provide minimum 45 degree lamp and lamp image cut-off unless otherwise specified.
- 3.4.3 Cone flanges shall be formed as an integral part of the cone. The flange's major surface shall be perpendicular to the cone axis.
- 3.4.4 The reflecting surface of the cone or reflector shall be tested for proper sealing. Test per ASTM B136-63T. If any stain is visible, the specimen shall not be considered to have been properly sealed. Reflector cones shall be free of manufactured defects. The reflector inner surface shall be free of water spotting and shall maintain a reflectivity ratio of not less than 83% on clear specular finish.
- 3.4.5 All alzak parabolic cones shall be guaranteed by the manufacturer against discoloration for a minimum of ten years and in the event of premature discoloration shall be replaced by the manufacturer (including both materials and the cost of labour) at no cost to the College.
- 3.4.6 Specular clear black reflector cones and parabolic louvers specified with the use of compact fluorescent lamps or triphosphor fluorescent shall be provided with clear non-iridescent coating.

3.5 Lighting Fixtures

- 3.5.1 Recessed Deep Cell Parabolic Fluorescent Luminaire for T-bar Ceiling
 - 3.5.1.1 The luminaire shall be nominal 600 x 1200 mm for use with two T-5 HO lamps.

- 3.5.1.2 The total overall height shall not exceed 200 mm.
- 3.5.1.3 The luminaire must incorporate a full perimeter black reveal.
- 3.5.1.4 Construction: nominal 175 mm deep, die formed code gauge, prime cold rolled steel. Die embossed housing has full length die formed stiffeners for added strength. Ballast/wireway cover, easily removed. Die formed captive lampholder bracket fully encloses lampholder wiring permitting easy lampholder replacement. Heavy gauge end plates. Iridescence suppressive specular aluminum silver reflector should be three cells wide by six cells long.
- 3.5.1.5 The luminaire must meet the Preferred Recommended cu-off performance as outlined by the Illuminating Engineering Society in standard publication RP1.
- 3.5.1.6 Total fixture efficiency must be at least 60%.
- 3.5.1.7 Painted parts to be treated with a 3-stage phosphate bonding process and finished with a high temperature baked white enamel, after fabrication.
- 3.5.1.8 Minimum reflectance 90%
- 3.5.1.9 A plastic dust cover which eliminates construction dust must be provided.
- 3.5.1.10 Provision for safety chains.
- 3.5.2 Suspended Direct/Indirect Fluorescent Luminaire
 - 3.5.2.1 Photometric Performance
 - 3.5.2.1.1 The fixture shall utilize an appropriate combination of louvre and reflector designs to achieve a photometric intensity distribution as required.
 - 3.5.2.1.2 The luminaire sections shall utilize T-5 HO lamps in cross-section and maintain an optical efficiency of no less than 72%.
 - 3.5.2.1.3 Louvre shall maintain 55° lamp shielding angle.
 - 3.5.2.2 Hardware
 - 3.5.2.2.1 All screws, rivets, clips welds, etc. used for fastening components shall be located and installed so as to present a smooth and unbroken appearance on visual examination of external sections of the fixture housing.
 - 3.5.2.3 Mechanical Attachment and Connection
 - 3.5.2.3.1 Modular luminaire sections shall be completely factory pre-assembled and fully reconfigurable such that no disassembly of the fixture is required prior to installation and/or post-occupancy

reconfiguration.

3.5.2.3.2 Attachment of luminaire sections, end caps and in-sections shall be accomplished utilizing internally fastened universal mounting and joining spring-loaded wedge-pin interface device interfitted with apertured retainer bars and formed alignment guides.

3.5.2.4 Support Hardware

3.5.2.4.1 Spacing of support hardware (4) along the fixture housings shall be in accordance with field measurements and as recommended by manufacturer.

3.5.2.4.2 All mounting devices shall be independently tested and verified to withstand loads up to 453 kg.

3.5.2.4.3 Luminaire shall maintain the capacity to be pendant supported by either or both aircraft cable and rigid pendants.

3.5.2.4.4 Connection at the fixture level shall accept either or both mounting arrangements by way of interchangeable assemblies.

3.5.2.4.5 Aircraft cable pendant assemblies shall be provided in locations and orientations required and should be standard for all the rooms.

3.5.2.4.6 The cable shall be 2.4 mm diameter 1 x 7 strand stainless steel. Cable shall be retained by a factory installed and tested stainless steel crimp and/or self-locking cable adjustment channel with infinite vertical adjustment.

3.5.2.4.7 Disengagement of the adjustment channel device shall not be possible without the deliberate insertion of specialized factory supplied release tools.

3.5.2.5 Optical Configuration

3.5.2.5.1 The optical system shall utilize one T-5 HO lamp or two T-5 HO lamps per cross-section as required. It shall be 20% downlight and 80% uplight.

3.5.2.6 Reflectors

3.5.2.6.1 Reflector assemblies shall be constructed of controlled colour iridescence, 0.5 mm thick processed specular aluminum with a minimum compound reflectance of 87%.

3.5.2.6.2 Optical transreflectors shall be constructed of low iridescence, 0.5 mm thick, processed highly specular aluminum with a

minimum compound reflectance of 95 percent.

3.5.2.7 Louvres

3.5.2.7.1 Louvre assemblies shall be constructed of controlled colour iridescence, 0.5 mm thick processed specular aluminum with a minimum compound reflectance of 87%.

3.5.2.7.2 Louvre cell dimensions shall measure no less than 53.97 mm deep, 139.7 mm long and 76.2 mm wide.

3.5.2.7.3 Louvre shall be constructed such that it provides a continuous appearance of 32 cells over 2438.4 mm and exhibits no visible luminance variance along or across the longitudinal axis.

3.5.2.8 Electrical Configuration

3.5.2.8.1 All luminaire sections shall be completely factory pre-wired to section ends such that no disassembly of the luminaire or wiring of/between ballasts is required during installation or reconfiguration.

3.5.2.8.2 Fixtures shall be constructed so as to hold T-5 HO fluorescent lamps.

3.5.2.8.3 Fluorescent sockets shall be medium bi-pin type in moulded thermosetting plastic housing.

3.5.2.8.4 Operation with electronic ballast.

3.5.2.9 Finishes

3.5.2.9.1 All metal components shall be cleaned and dressed free of burrs, tool and die marks prior to finishing.

3.5.2.9.2 There shall be no visually perceptible difference in colour between finished components when viewed under daylight or fluorescent lighting.

3.5.2.9.3 Finished fixtures shall present no visible light leaks at fixture mitres, joints and end caps.

3.5.2.9.4 Specular reflectors shall be free of roller or other obvious processing marks.

3.5.2.9.5 Exterior finishes shall be electrostatically applied medium gloss, high-solids polyester baked enamel, standard white.

3.5.2.10 Acceptable materials (or approved equal): Ledalite.

3.5.3 600 x 1200 mm Recessed Fluorescent Luminaire in T-bar Ceiling.

- 3.5.3.1 Heavy gauge steel, embossed for extra rigidity.
- 3.5.3.2 Integral T-bar clips.
- 3.5.3.3 Frame hinge from either side.
- 3.5.3.4 2 x T-5 HO, electronic ballast.
- 3.5.3.5 Clear prismatic acrylic diffuser.
- 3.5.4 Open Wall Wash Pot Light
 - 3.5.4.1 Full circle kicker reflector to direct a uniform wash light to adjacent walls. The pattern shall be free from spikes, striations or dropouts and shall feature wide lateral distribution. The downlight component shall be uniform with a soft edge to blend with nearby units.
 - 3.5.4.2 construction shall allow easy access to all components. A sturdy steel housing shall protect the reflectors which are rigidly joined to assure predictable performance. The aperture throat shall fit ceilings up to 25 mm thick. Ballast and lamp service from below.
 - 3.5.4.3 32 W triple tube compact fluorescent, electronic ballast.
- 3.5.5 Open Reflector Downlight
 - 3.5.5.1 The primary reflector shall maximize the output of the energy efficient lamps. The parabolic shielding cone shall offer low brightness visual comfort from all normal viewing angles.
 - 3.5.5.2 construction shall allow easy access to all components. Aperture throat shall permit use in standard ceilings up to 50 mm thick. Airflow design shall assure cool fixture temperature for optimal lamp performance. A steel housing shall protect the reflectors and assure their proper relationship for maximum performance. Ballast and lamp service from below.
 - 3.5.5.3 32 W triple tube compact fluorescent, electronic ballast.
- 3.5.6 Whiteboard Lighting
 - 3.5.6.1 The luminaire housing shall be constructed of die formed code gauge cold rolled steel. The reflector assembly shall be constructed of anodized aluminum and designed to present a clean uninterrupted reflecting surface. The kicker reflector shall be highly polished extruded aluminum and not adjustable. The kicker reflector shall shield the lamp completely from room side and 9° from nadir on the wall side. Ballast shall be housed above front reflector and shall be totally accessible from below. Neither the optical system nor the kicker should be removed for lamp maintenance.

- 3.5.6.2 The reflector assembly shall be constructed of semi-specular low iridescent anodized aluminum (LD).
- 3.5.6.3 Precise optics shall provide excellent spread laterally, enabling wide fixture spacings.
- 3.5.7 Other luminaires as required to suit the purpose of the Facility. Luminaire shall be of commercial grade meeting the general requirements and quality of the above.

3.6 Exit Lights

- 3.6.1 Exit fixtures shall consist of a one-piece die-cast extruded aluminum black frame with brushed aluminum face and red letters with universal arrows.
- 3.6.2 Lettering shall be made with at least 20 mm wide strokes and be at least 150 mm high, reading EXIT.
- 3.6.3 The fixture shall be illuminated with multiple miniature light emitting diodes (LEDs) attached to light panel on top and on bottom of the fixture. LEDs shall be backed by manufacturer's 25-year replacement warranty. Lettering shall be visible during the day.
- 3.6.4 The light panel shall consume five watt or less and operate continuously without relamping for a period of 219,000 hours (25 years).
- 3.6.5 Suitable for operation at 347 volts A.C. and 24 volts D.C.

3.7 Unit Equipment for Emergency Lighting

- 3.7.1 Unit equipment for emergency lighting to be CSA certified. To CSA C22.2 No. 141.
- 3.7.2 The emergency lighting system shall consist of fully automatic unit equipment with heads attached or remote as required.
- 3.7.3 Each unit shall contain a fully automatic solid-state charger with test switch "ON" and "CHARGE" LED pilot lights.
- 3.7.4 The charger shall have output regulation of ± 0.1 volts for $\pm 10\%$ input variation and shall have an automatic equalizer feature.
- 3.7.5 The unit shall contain a sealed transfer circuit and low voltage disconnect circuit.
- 3.7.6 The charger shall feature phase loss and brownout protection.
- 3.7.7 The battery shall have a design life of 10 years and be 10 years maintenance free.
- 3.7.8 Suitable for 347 Volts supply with 24 Volts D.C. output with sufficient

- 3.7.9 ampacity to provide 91% voltage after 2 hour operation with connected load.
- 3.7.10 The batteries shall have minimum capacity of 300 W each for building interior application.
- 3.7.11 Complete with 347 V plug.
- 3.7.12 Lamp head and stem shall be injection moulded, impact resistant, flame retardant A.B.S.
- 3.7.13 Lens shall be inverse concave design and fully adjustable for aisle or area distribution during installation without the need to energize the lamp.
- 3.7.14 Visual identification of distribution shall be provided through position of adjustment pins.
- 3.7.15 Lamp shall be supplied with appropriate canopy for installation on any four inch octagon box.
- 3.7.16 Housing shall be designed to allow for lamp replacement.
- 3.7.17 Lamps shall be 24 volts, 12 watts quartz halogen composite beam.
- 3.7.18 Integral heads: standard double fixture mounted on unit equipment.
- 3.7.19 Remote heads: double, wall or ceiling mounted standard fixture, as required.

4 INSTALLATION

- 4.1 All fixtures in continuous lines or rows to be carefully aligned so that all rows appear as straight lines. Crooked lines or misplaced fixtures will not be acceptable.
- 4.2 Fixtures will not be mounted above pipes, ducts or equipment. Provide longer hangers to clear obstructions. Layout of all other trades shall be checked on the job and planned cooperatively to avoid conflicting installations.
- 4.3 At least 12 mm of free air space will be allowed between recessed fixture enclosures and any combustible material other than that to which they are attached.
- 4.4 All fixtures will be installed in the standard manner for the type of fixture and in accordance with the manufacturer's instructions. Fixtures shall not be installed to hang over stair tread areas.
- 4.5 Individual fixture supports and hangers will be capable of supporting independently the dead load of the fixture plus 115 kg.
- 4.6 All lamps will be of the type suitable for the fixture in which they are installed. Remove all defective ballasts, sockets, diffusers and wiring and replace with new equipment as required.

- 4.7 Ensure that circuit breakers supplying exit lights and night lights are equipped with “lock-on” devices.
- 4.8 Install exit lights in accordance with the Ontario Building Code.
- 4.9 Connect fixtures to exit light circuits and to local emergency battery unit. Design Builder to use deep octagon outlet box.
- 4.10 Mounting heights of exit lights to be 2500 mm unless noted otherwise.
- 4.11 In general, each emergency battery unit shall supply power to the fixtures located in the same room/area. Install unit equipment and remote mounted fixtures as required by the Ontario Building Code. Maximum spacing of unit mounted and/or remote mounted double fixtures shall not exceed 12 m to maintain minimum of 10 lux illumination at floor level for all exit routes.
- 4.12 Direct heads to illuminate path of exit route.
- 4.13 Provide a separate wiring run to each remote single or two lamp fixture. Size wire to limit voltage drop to 5%.
- 4.14 Provide a separate wiring run to each local exit light fixture. Size wire to limit voltage drop to 5%.
- 4.15 Wires and cables sized in accordance with the electrical safety code installed in its own conduit system.
- 4.16 Test for function.

II WIRING DEVICES

1 GENERAL

- 1.1 Wiring devices shall be provided in sufficient numbers to suit the function of the space. Stainless steel 1 mm thick cover plates shall be provided for all wiring devices. For exterior installations, provide weatherproof double-lift spring-loaded cast aluminum cover plates, complete with gaskets for duplex receptacles.

2 DESIGN

- 2.1 Provide duplex receptacles for the following spaces as indicated.

<u>Area</u>	<u>Number of duplex receptacles</u>	<u>Circuit Loading</u>
Office	standard (std),	4 std per circuit
	1 isolated ground (IG)	3 IG per circuit
Standard classrooms	1 IG and 1 std at front of class,	5 std per circuit
	2 std on every other walls	3 IG per circuit

	1 std outlet for projection screen	1 dedicated per projection screen
	Circuits terminated in ceiling space for future computer lab	Same as computer lab
Computer labs	1 IG per two workstations	2 IG per circuit
	1 IG per printer,	1 dedicated per printer
	1 std on each wall,	6 std per circuit
	1 std outlet for projection screen	1 dedicated per projection screen
Laboratories	to meet program requirements	
Communication	8 IG; 1 std	1 IG per circuit
Closets		1 std per circuit
Corridors	1 20A every 10 m	4 std per circuit
Service rooms	1 20A	4 std per circuit
Janitors closets	1 20A	4 std per circuit
Copier	To suit	Dedicated on timer.
Vending machines	2 std, one 20 A	Each on dedicated circuits

2.2 Number of duplex receptacles for each space shall meet the requirements of the program. Provide direct connection to equipment where required. Size wiring and protection to meet the Electrical Safety Code.

2.3 Ground fault interrupters (breakers) to be used for receptacles in all wet location areas.

2.4 Colour Coding

2.4.1 Duplex receptacles shall be colour coded to easily identify the loads they are intended to serve. Colour coding shall be as follows:

2.4.1.1 Ivory for general receptacle roads

2.4.1.2 Orange for isolated ground receptacles for computer loads

2.4.1.3 Grey for dedicated receptacles for printers

2.4.1.4 Red for emergency receptacle loads (if applicable).

2.5 Clocks shall be provided in spaces as required. All clocks shall be connected to its own 120 V circuit.

3 MATERIALS

3.1 Switches

- 3.1.1 Local switches to be specification grade 20 A, 1 P, 3 Way where required, rated 120V for 120 V loads and 347V for 347 V loads.

3.2 Receptacles

- 3.2.1 Duplex receptacles to be 120 V, 15A, U around suitable for #10 AWG side wiring, outlets to be specification grade for the application indicated. Outlets used for electronic systems to be isolated ground type.
- 3.2.2 Receptacles in washrooms or external are to be GFI type
- 3.2.3 Acceptable manufacturer for switches and receptacles: Pass & Seymour; Hubbell; Bryant.
- 3.2.4 Cover Plates
 - 3.2.4.1 Cover plates to be as required in finished areas to be stainless steel, vertically brushed, 1mm thick. Industrial areas to be galvanized steel for surface or flush application.
- 3.2.5 Clocks
 - 3.2.5.1 Plug-in model, CSA listed to operate at 120 V, 60 Hz complete with plug and 1.2 m supply cord. Surface mounted, glass lens, 300 mm size, 12-hour.

4 INSTALLATION

- 4.1 Install single throw switches with handle in “UP” position when switch closed.
- 4.2 Install switches in gang type outlet box when more than one switch is required in one location.
- 4.3 Install receptacles in gang type outlet box when more than one receptacle is required in one location.
- 4.4 Where split receptacle has one portion switches, mount vertically and switch upper portion.
- 4.5 Protect stainless steel cover plate finish with paper or plastic film until painting and other work is finished.
- 4.6 Install suitable common cover plates where wiring devices are grouped.
- 4.7 Do not use cover plates meant for flush outlet boxes on surface-mounted boxes.
- 4.8 Install clocks where required.

III **BRANCH WIRING**

1 **GENERAL**

- 1.1 All raceway and wiring sizing and installation shall be in conformance with the Ontario Electrical Safety Code, latest edition.

2 **DESIGN**

2.1 Conduits

- 2.1.1 Conduits shall be concealed in all areas of the College except that conduit installed in mechanical and electrical service rooms, and in unfinished areas, may be installed exposed. All conduits shall be installed to conserve headroom in exposed locations and cause minimum interference in spaces in which they pass.
- 2.1.2 All conduits shall run parallel and/or perpendicular to the building lines and shall be grouped wherever possible. Conduits shall not pass through structural members unless approved in writing by the Engineer. As well, conduits shall be located no less than 75 mm parallel to steam or hot water lines with a minimum of 25 mm at crossovers.
- 2.1.3 The following types of conduit shall be used:
- 2.1.3.1 Rigid galvanized steel where subject to mechanical injury,
- 2.1.3.2 Electric metallic tubing (EMT) for general use except that they shall not be installed in cast concrete,
- 2.1.3.3 Rigid PVC conduit for underground and corrosive areas,
- 2.1.3.4 Liquid-tight flexible metal conduit for final connection to motors or vibrating equipment. Maximum length: 2 metres,
- 2.1.3.5 Flexible metal conduit for connection recessed incandescent fixtures without a prewired outlet box, connection to recessed fluorescent lighting fixtures and work in partitions. Maximum length: 3 metres,
- 2.1.3.6 Minimum size of conduit shall be 13 mm. For telephone and data wiring, minimum size shall be 19 mm or as recommended by the network manufacturer.
- 2.1.3.7 Use surface non-metallic raceways in all computer labs for power and data distribution.
- 2.1.3.8 Modular wiring systems may be used for certain parts of the project and must be approved by Algonquin College.

2.2 Fastening and Supports

- 2.2.1 Conduit shall be supported using clips, spring loaded bolts, cable clamps designed as accessories to basic channel members.
- 2.2.2 Fasten exposed conduit to building construction or support system using straps :
 - 2.2.2.1 One-hole steel straps to secure surface conduits and cables 50 mm and smaller.
 - 2.2.2.2 Two-hole steel straps for conduits and cables larger than 50 mm.
 - 2.2.2.3 Beam clamps to secure conduit to exposed steel work.
- 2.2.3 Suspended support systems :
 - 2.2.3.1 Support individual conduit runs with 6 mm diameter threaded rods and spring clips.
 - 2.2.3.2 Support 2 or more conduits on channels supported by 6 mm diameter threaded rod hangers where direct fastening to building construction is impractical.
- 2.2.4 For surface mounting of two or more conduits, channels at spacing as per Code requirements shall be used.
- 2.2.5 Adequate support shall be provided for raceways and cables dropped vertically to equipment where there is no wall support.
- 2.2.6 Wire lashing or perforated strap shall not be used to support or secure raceways.
- 2.2.7 Supports or equipment installed for other trades shall not be used for conduit support except with permission of other trade and approval of Owner.

2.3 Wires and Cables

- 2.3.1 All necessary wiring and raceways shall be provided for all the different systems between the panels and the loads.

3 MATERIALS

3.1 Surface Non-Metallic Raceway

- 3.1.1 Surface non-metallic raceway shall be used for branch wiring and data network wiring in computer labs. The non-metallic raceway system shall be UL and CSA listed and exhibit non-flammable self-extinguishing characteristics, tested to comparable specifications of UL94V-O. The raceway base, cover divider and all fittings shall be manufactured of rigid compound, ivory in colour. The raceway shall include the number of duplex receptacle and data outlets, sufficient in numbers to accommodate

the function of the space.

3.1.2 Acceptable material: Wiremold Series 5400.

3.2 Cable Troughs

3.2.1 Cable troughs shall be galvanized steel ventilated type, Class C1 to CSA C22.2 No. 126-M. Size to suit the program requirement. Horizontal elbows, end plates, drop outs, vertical risers and drop, tees, wyes, expansion joints and reducers where required. The cable trough system shall be installed in ceiling space and be closely coordinated with existing conditions and other trades. As a minimum, support the cable troughs on both sides, 2 m apart or as recommended by the manufacturer using trapeze hanger system.

3.3 Service Poles

3.3.1 The indoor service pole system shall consist of the indoor service pole multi-outlet assembly for power branch circuit wiring and communication cabling. The service pole channel shall be steel, ivory baked enamel finish with cross-section of 75 mm x 60mm with two separate compartments. One compartment shall be factory wired with duplex receptacles in sufficient numbers for its intended use. The second compartment shall be used for field wiring of data network cabling.

3.3.2 The service pole shall be listed for field modifications, changes and additions of receptacles, devices, and circuits. Nominal length of poles shall be from floor to ceiling with plus or minus 50 mm adjustment for a total of 100 mm adjustment.

3.3.3 Service poles shall be used where a cluster of desks or workstations are used in the centre of a room in which providing services from below is not feasible.

3.4 Conductors

3.4.1 Stranded for 10 AWG and larger. Minimum size : 12 AWG.

3.4.2 Copper conductors: size as required, with 1000 V insulation of chemically cross-linked thermosetting polyethylene material rated RW90 and RWU90 for working temperature of -7°C.

3.4.3 Minimum branch circuit conductor size shall be No. 12 AWG for power circuits, and 14 AWG for control circuits.

3.5 Armoured Cables

3.5.1 Copper conductors: size as required, with 1000 V insulation of chemically cross-linked thermosetting polyethylene material rated RW90 and RWU90 for working temperature of -7°C.

3.5.2 Type AC90.

3.5.3 Armour : interlocking type fabricated from aluminum strip.

4 INSTALLATION

4.1 Install wiring in conduit systems. Group cables wherever possible. All cables in suspended ceiling shall be properly strapped.

4.2 Install armoured cables only for final connection to motors in dry areas, connection to recessed incandescent fixtures without a prewired outlet box, connection to surface or recessed fluorescent fixtures and work in stud wall partitions. Maximum length of flexible metal conduit allowed is 3.0 m.

4.3 Install complete cabletrough system and coordinate installation with all other trades.

4.4 Support cabletrough on both sides, as recommended by the manufacturer.

4.5 Remove sharp burrs or projections to prevent damage to cables or injury to personnel.

4.6 Completeness:

4.6.1 Work shall include furnishing and installing a complete cable tray system which shall include, but not be limited to, straight lengths, fittings such as elbows, tees, crosses, etc., together with all necessary connectors.

4.7 Install pull boxes in inconspicuous but accessible locations. All main conduit runs and pull boxes to be installed in corridor system.

4.8 Install pull boxes so as not to exceed 30 m of conduit run between pull boxes.

4.9 Support boxes independently of connecting conduits.

4.10 Fill boxes with paper, sponges or foam or similar approved material to prevent entry of debris during construction. Remove upon completion of work.

4.11 For flush installations mount outlets flush with finished wall using plaster rings to permit wall finish to come within 6 mm of opening.

4.12 Provide correct size of openings in boxes for conduit, mineral insulated and armoured cable connections. Reducing washers are not allowed.

End of Section