

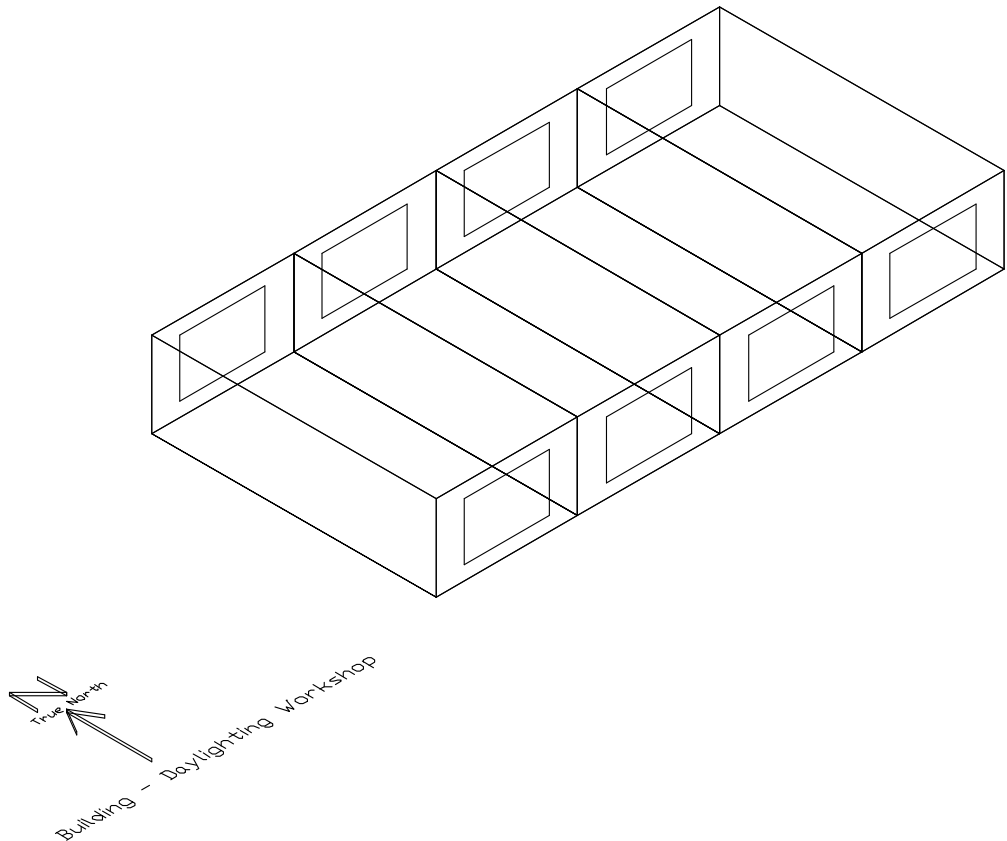
EnergyPlus Exercise Daylighting 1

Daylighting, ResultsViewer

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General Description

This workshop illustrates use of the daylighting controls and the daylighting illuminance map. The geometry is a building with 4 identical zones, each with north and south exterior walls and adiabatic east and west walls. Initially all of the zones are the same. Various daylighting options will be added and compared. Run for four different Chicago, IL design days. After a successful simulation you can change and modify parameters and report variables to explore further. This workshop also introduces ResultsViewer to graph results.



Basic File Description

1 story building divided into identical zones, each with north and south exterior walls and adiabatic east and west walls. Each zone is 5m wide by 10m deep by 3m high. There are windows on the north and south walls. The windows are double pane 3mm LoE Clear glass with 13mm Argon gas layer.

Weather Data Description

Four Chicago design days:

January 21, Winter, clear
April 21, Spring, clear
April 22, Spring, cloudy
July 21, Summer, clear

HVAC System Description

ZoneHVAC:IdealLoadsAirSystem for cooling and heating with setback during unoccupied hours.

Instructions

Part1 – Add daylighting controls and compare behavior for different scenarios

In this section we will take the basic building and add daylighting controls with various configurations

1. Run ExerciseDaylighting1.idf to verify that all four zones are identical (same heating, cooling, and lighting loads).
Note: Select "No weather file" from the pull-down list of recent weather files in EP-Launch. This is all based on design days in the idf.
2. Save ExerciseDaylighting1.idf as ExerciseDaylighting1A.idf and add Daylighting:Controls to zones 2, 3, and 4:
 - Use defaults for most values (1 reference point, 500 lux illuminance setpoint, entire zone controlled by first reference point, continuous lighting control, 0.3 minimum input power fraction).
 - In all three zones, set the azimuth angle of view direction to 0 (the value must be entered as "0.0" if using IDF Editor).
 - In all three zones, the reference point X-coordinate is 2.5m, and the z-coordinate is 0.8m
 - In Zone 2, set the reference point Y-coordinate to 2m, 5m in Zone 3, and 8m in Zone 4.
 - Run and look in the RDD file for output variables related to daylighting, and add new output variables to idf. Suggested ones of interest:
Daylight Illum at Ref Point 1
Glare Index at Ref Point 1
Ltg Power Multiplier from Daylighting
 - Also add object to produce SQLite output for ResultsViewer
Output:SQLite, Simple;

- Run simulation.
- Inspect results in the Variables output file (spreadsheet). *Note the differences between the four zones for a given design day and the differences between design days for a given zone. See the reference points as circles in the DXF drawing.*
- Open OpenStudio-ResultsViewer (from Start → All Programs).
- Use File → Open and browse to open ExerciseDaylighting1A.sql
- Switch to "Tree View" and locate the variables for first simulation day in the tree "CHICAGO_IL_USA Cooling .4% Conditions DB=>MWB".
- Shift-click to select the three "Daylight Illum at Ref Point 1" for the three daylighting zones for the. Then right-click on one of the highlighted variables and select "Line Plot" or double-click. This will display a line plot comparing the illuminance level at the daylighting reference points in the three zones.
- Repeat plot for the other three design days and for other variables such as:
 - Ltg Power Multiplier from Daylighting
 - Zone Lights Electric Consumption
 - Ideal Loads Air Heating Rate
 - Ideal Loads Air Sensible Cooling Rate

Hint: if you want to keep these plots to compare with later runs, leave ResultsViewer open. For later runs, you may open another instance of ResultsViewer, or you may open another output file in the ResultsViewer that is already open.

3. Save ExerciseDaylighting1A.idf as ExerciseDaylighting1B.idf:
 - Delete the four north windows and related Output:Variable objects.
 - Run and inspect results. *Note how Zone 4 never fully dims the lights now on the last two design days.*

Part2 – Change lighting level, add exterior shading, window shades, and illuminance map

In this section we will use the same daylighting controls in each zone and alter other features to see the impact on the daylighting calculations.

4. Save ExerciseDaylighting1B.idf as ExerciseDaylighting1C.idf:
 - Change the reference point Y-coordinate in Zone 2 and Zone 4 to be 5m.
 - Add the same daylighting control to Zone 1 as in the other zones.
 - Run and verify that Zones 1 to 4 have the same results for heating, cooling, and lighting loads.

5. Save ExerciseDaylighting1C.idf as ExerciseDaylighting1D.idf:
 - Change the design lighting level in Zone 2 to be 10W, Zone 3 100 W, and Zone 4 10000W.
 - Run and review results. *Note how the daylighting calculations do not know how intense the electric lighting is. The user must verify that the electric lighting is adequate to provide the desired level of illumination. It is also not sensitive to scheduled changes in lighting levels.*
6. Open ExerciseDaylighting1C.idf (the one where all zones are the same) and save as ExerciseDaylighting1E.idf:
 - Add an exterior shading surface Shading:Building:Detailed blocking the Zone 2 south window. (The global coordinate location of the Zone 2 south window is [6,0,2.5] [6,0,0.5] [9,0,0.5] [9,0,2.5]. Place the shade slightly south of the window and larger than the window.
Note: You may prefer to use OpenStudio in SketchUp to add this shade.
 - Using IDF Editor, open the WindowShadeMaterials.idf dataset file. Copy the "MEDIUM REFLECT - MEDIUM TRANS SHADE" shade type from the dataset file and paste it into ExerciseDaylighting1E.idf.
 - Using IDF Editor add a WindowProperty:ShadingControl to the Zone 3 South Window. For controls, use interior shade, "OnIfHighSolarOnWindow", set point 400 W/m², not scheduled, no glare control, shade material "MEDIUM REFLECT - MEDIUM TRANS SHADE".
*Note: Remember to create a WindowProperty:ShadingControl object, **and** to add the Shading Control Name name to the FenestrationSurface:Detailed object for the window.*
 - Make the surfaces in Zone 4 dark by creating a new material and construction with an inside visible absorptance of 1.0. Then change the construction names for the surfaces in Zone 4.
 - Run and review results, comparing with the results from ExerciseDaylighting1C.
7. Save ExerciseDaylighting1E.idf (or whichever case you prefer) as ExerciseDaylighting1F.idf:
 - Turn on the daylighting illuminance map report (Output:IlluminanceMap) for one of the zones. Set the Z-value to 0 (zero), and use a 10x10 grid. The X minimum and maximum coordinates should be set to 0 and 5, respectively. The Y minimum and maximum coordinates should be set to 0 and 10, respectively.
 - Run the simulation.
 - To see the illuminance map in Excel, open ExerciseDaylighting1FMap.csv, then open the ExerciseDaylighting1F.xls file. The copy/paste one day of data (hours 8 through 16) from the ExerciseDaylighting1FMap.csv file into the workbook to see graphs of the data.

- To see the illuminance map in ResultsViewer, open ResultsViewer and open ExerciseDaylighting1F.sql. Find the Illuminance Map in the list of variables (list view will be at the end, tree view will be in the middle. Double-click on "Illuminance Map" and a flood plot will be displayed representing the map at a single point in time. Use the slider or spinner control below the plot to move to different times of day and different days of year (the four design days all have a different date.)

Notes: The bottom of the flood plot is the south wall/window. As you move through time, the scale is changing to cover the range of values for that hour. So, even though the color pattern may look similar, the illuminance level may be quite different from one hour to the next.

8. If time allows, explore other variations.
9. You may also open these idf files in OpenStudio which displays the daylighting reference points in the drawing and has a daylighting tool to edit the daylighting controls.

List of New Objects

This is a listing of new objects added or modified in this Exercise.

Try not to look at this section until you have completed the Exercise.

Exercise Daylighting 1A

Daylighting:Controls,

```

Zone 2,                !- Zone Name
1,                    !- Total Daylighting Reference Points
2.5,                  !- X-Coordinate of First Reference Point {m}
2,                    !- Y-Coordinate of First Reference Point {m}
0.8,                  !- Z-Coordinate of First Reference Point {m}
,                     !- X-Coordinate of Second Reference Point {m}
,                     !- Y-Coordinate of Second Reference Point {m}
0.8,                  !- Z-Coordinate of Second Reference Point {m}
1,                    !- Fraction of Zone Controlled by First Reference Point
,                     !- Fraction of Zone Controlled by Second Reference Point
500,                  !- Illuminance Setpoint at First Reference Point {lux}
500,                  !- Illuminance Setpoint at Second Reference Point {lux}
1,                    !- Lighting Control Type
0,                    !- Glare Calculation Azimuth Angle of View Direction
Clockwise from Zone y-Axis {deg}
22,                   !- Maximum Allowable Discomfort Glare Index
0.3,                  !- Minimum Input Power Fraction for Continuous Dimming
Control
0.2,                  !- Minimum Light Output Fraction for Continuous Dimming
Control
1,                    !- Number of Stepped Control Steps
1;                    !- Probability Lighting will be Reset When Needed in
Manual Stepped Control

```

```

Daylighting:Controls,
    Zone 3,                !- Zone Name
    1,                     !- Total Daylighting Reference Points
    2.5,                   !- X-Coordinate of First Reference Point {m}
    5,                     !- Y-Coordinate of First Reference Point {m}
    0.8,                   !- Z-Coordinate of First Reference Point {m}
    ,                      !- X-Coordinate of Second Reference Point {m}
    ,                      !- Y-Coordinate of Second Reference Point {m}
    0.8,                   !- Z-Coordinate of Second Reference Point {m}
    1,                     !- Fraction of Zone Controlled by First Reference Point
    ,                     !- Fraction of Zone Controlled by Second Reference Point
    500,                   !- Illuminance Setpoint at First Reference Point {lux}
    500,                   !- Illuminance Setpoint at Second Reference Point {lux}
    1,                     !- Lighting Control Type
    0,                     !- Glare Calculation Azimuth Angle of View Direction
    Clockwise from Zone y-Axis {deg}
    22,                    !- Maximum Allowable Discomfort Glare Index
    0.3,                   !- Minimum Input Power Fraction for Continuous Dimming
    Control
    0.2,                   !- Minimum Light Output Fraction for Continuous Dimming
    Control
    1,                     !- Number of Stepped Control Steps
    1;                     !- Probability Lighting will be Reset When Needed in
    Manual Stepped Control

Daylighting:Controls,
    Zone 4,                !- Zone Name
    1,                     !- Total Daylighting Reference Points
    2.5,                   !- X-Coordinate of First Reference Point {m}
    8,                     !- Y-Coordinate of First Reference Point {m}
    0.8,                   !- Z-Coordinate of First Reference Point {m}
    ,                      !- X-Coordinate of Second Reference Point {m}
    ,                      !- Y-Coordinate of Second Reference Point {m}
    0.8,                   !- Z-Coordinate of Second Reference Point {m}
    1,                     !- Fraction of Zone Controlled by First Reference Point
    ,                     !- Fraction of Zone Controlled by Second Reference Point
    500,                   !- Illuminance Setpoint at First Reference Point {lux}
    500,                   !- Illuminance Setpoint at Second Reference Point {lux}
    1,                     !- Lighting Control Type
    0,                     !- Glare Calculation Azimuth Angle of View Direction
    Clockwise from Zone y-Axis {deg}
    22,                    !- Maximum Allowable Discomfort Glare Index
    0.3,                   !- Minimum Input Power Fraction for Continuous Dimming
    Control
    0.2,                   !- Minimum Light Output Fraction for Continuous Dimming
    Control
    1,                     !- Number of Stepped Control Steps
    1;                     !- Probability Lighting will be Reset When Needed in
    Manual Stepped Control

Output:Variable,
    *,                     !- Key Value
    Daylight Illum at Ref Point 1, !- Variable Name
    Hourly;                !- Reporting Frequency

Output:Variable,
    *,                     !- Key Value
    Glare Index at Ref Point 1,  !- Variable Name
    Hourly;                !- Reporting Frequency

Output:Variable,
    *,                     !- Key Value
    Ltg Power Multiplier from Daylighting, !- Variable Name
    Hourly;                !- Reporting Frequency

```

```
Output:SQLite,
Simple;                                !- Option Type
```

Exercise Daylighting 1B

No new objects. Some objects deleted.

Exercise Daylighting 1C

Modified objects:

```
Daylighting:Controls,
Zone 2,                                !- Zone Name
1,                                     !- Total Daylighting Reference Points
2.5,                                  !- X-Coordinate of First Reference Point {m}
5,                                    !- Y-Coordinate of First Reference Point {m}
0.8,                                  !- Z-Coordinate of First Reference Point {m}
,                                     !- X-Coordinate of Second Reference Point {m}
,                                     !- Y-Coordinate of Second Reference Point {m}
0.8,                                  !- Z-Coordinate of Second Reference Point {m}
1,                                     !- Fraction of Zone Controlled by First Reference Point
,                                     !- Fraction of Zone Controlled by Second Reference Point
500,                                  !- Illuminance Setpoint at First Reference Point {lux}
500,                                  !- Illuminance Setpoint at Second Reference Point {lux}
1,                                     !- Lighting Control Type
0,                                     !- Glare Calculation Azimuth Angle of View Direction
Clockwise from Zone y-Axis {deg}
22,                                   !- Maximum Allowable Discomfort Glare Index
0.3,                                  !- Minimum Input Power Fraction for Continuous Dimming
Control
0.2,                                  !- Minimum Light Output Fraction for Continuous Dimming
Control
1,                                     !- Number of Stepped Control Steps
1;                                    !- Probability Lighting will be Reset When Needed in
Manual Stepped Control

Daylighting:Controls,
Zone 4,                                !- Zone Name
1,                                     !- Total Daylighting Reference Points
2.5,                                  !- X-Coordinate of First Reference Point {m}
5,                                    !- Y-Coordinate of First Reference Point {m}
0.8,                                  !- Z-Coordinate of First Reference Point {m}
,                                     !- X-Coordinate of Second Reference Point {m}
,                                     !- Y-Coordinate of Second Reference Point {m}
0.8,                                  !- Z-Coordinate of Second Reference Point {m}
1,                                     !- Fraction of Zone Controlled by First Reference Point
,                                     !- Fraction of Zone Controlled by Second Reference Point
500,                                  !- Illuminance Setpoint at First Reference Point {lux}
500,                                  !- Illuminance Setpoint at Second Reference Point {lux}
1,                                     !- Lighting Control Type
0,                                     !- Glare Calculation Azimuth Angle of View Direction
Clockwise from Zone y-Axis {deg}
22,                                   !- Maximum Allowable Discomfort Glare Index
0.3,                                  !- Minimum Input Power Fraction for Continuous Dimming
Control
0.2,                                  !- Minimum Light Output Fraction for Continuous Dimming
Control
1,                                     !- Number of Stepped Control Steps
1;                                    !- Probability Lighting will be Reset When Needed in
Manual Stepped Control
```

New object:

```
Daylighting:Controls,
  Zone 1,                !- Zone Name
  1,                    !- Total Daylighting Reference Points
  2.5,                  !- X-Coordinate of First Reference Point {m}
  5,                    !- Y-Coordinate of First Reference Point {m}
  0.8,                  !- Z-Coordinate of First Reference Point {m}
  ,                     !- X-Coordinate of Second Reference Point {m}
  ,                     !- Y-Coordinate of Second Reference Point {m}
  0.8,                  !- Z-Coordinate of Second Reference Point {m}
  1,                    !- Fraction of Zone Controlled by First Reference Point
  ,                     !- Fraction of Zone Controlled by Second Reference Point
  500,                  !- Illuminance Setpoint at First Reference Point {lux}
  500,                  !- Illuminance Setpoint at Second Reference Point {lux}
  1,                    !- Lighting Control Type
  0,                    !- Glare Calculation Azimuth Angle of View Direction
Clockwise from Zone y-Axis {deg}
  22,                  !- Maximum Allowable Discomfort Glare Index
  0.3,                  !- Minimum Input Power Fraction for Continuous Dimming
Control
  0.2,                  !- Minimum Light Output Fraction for Continuous Dimming
Control
  1,                    !- Number of Stepped Control Steps
  1;                   !- Probability Lighting will be Reset When Needed in
Manual Stepped Control
```

Exercise Daylighting 1D

Modified objects:

```
Lights,
  Zone 2 Lights 1,      !- Name
  Zone 2,               !- Zone Name
  LIGHTS-1,             !- Schedule Name
  LightingLevel,        !- Design Level Calculation Method
  10,                   !- Lighting Level {W}
  ,                     !- Watts per Zone Floor Area {W/m2}
  ,                     !- Watts per Person {W/person}
  0.0,                  !- Return Air Fraction
  0.59,                 !- Fraction Radiant
  0.2,                  !- Fraction Visible
  1.0,                  !- Fraction Replaceable
  GeneralLights;        !- End-Use Subcategory

Lights,
  Zone 3 Lights 1,      !- Name
  Zone 3,               !- Zone Name
  LIGHTS-1,             !- Schedule Name
  LightingLevel,        !- Design Level Calculation Method
  100,                  !- Lighting Level {W}
  ,                     !- Watts per Zone Floor Area {W/m2}
  ,                     !- Watts per Person {W/person}
  0.0,                  !- Return Air Fraction
  0.59,                 !- Fraction Radiant
  0.2,                  !- Fraction Visible
  1.0,                  !- Fraction Replaceable
  GeneralLights;        !- End-Use Subcategory
```



```

Lights,
  Zone 4 Lights 1,      !- Name
  Zone 4,               !- Zone Name
  LIGHTS-1,            !- Schedule Name
  LightingLevel,       !- Design Level Calculation Method
  10000,               !- Lighting Level {W}
  ,                    !- Watts per Zone Floor Area {W/m2}
  ,                    !- Watts per Person {W/person}
  0.0,                 !- Return Air Fraction
  0.59,                !- Fraction Radiant
  0.2,                 !- Fraction Visible
  1.0,                 !- Fraction Replaceable
  GeneralLights;       !- End-Use Subcategory

```

Exercise Daylighting 1E

New objects:

```

Shading:Building:Detailed,
  Zone 2 Window Obstruction, !- Name
  ,                          !- Transmittance Schedule Name
  4,                          !- Number of Vertices
  6,                          !- Vertex 1 X-coordinate {m}
  -1,                         !- Vertex 1 Y-coordinate {m}
  3,                          !- Vertex 1 Z-coordinate {m}
  6,                          !- Vertex 2 X-coordinate {m}
  -1,                         !- Vertex 2 Y-coordinate {m}
  0,                          !- Vertex 2 Z-coordinate {m}
  9,                          !- Vertex 3 X-coordinate {m}
  -1,                         !- Vertex 3 Y-coordinate {m}
  0,                          !- Vertex 3 Z-coordinate {m}
  9,                          !- Vertex 4 X-coordinate {m}
  -1,                         !- Vertex 4 Y-coordinate {m}
  3;                          !- Vertex 4 Z-coordinate {m}

WindowMaterial:Shade,
  MEDIUM REFLECT - MEDIUM TRANS SHADE, !- Name
  0.4,                                !- Solar Transmittance
  0.5,                                !- Solar Reflectance
  0.4,                                !- Visible Transmittance
  0.5,                                !- Visible Reflectance
  0.9,                                !- Thermal Hemispherical Emissivity
  0.0,                                !- Thermal Transmittance
  0.005,                              !- Thickness {m}
  0.1,                                !- Conductivity {W/m-K}
  0.05,                               !- Shade to Glass Distance {m}
  0.5,                                !- Top Opening Multiplier
  0.5,                                !- Bottom Opening Multiplier
  0.5,                                !- Left-Side Opening Multiplier
  0.5,                                !- Right-Side Opening Multiplier
  0.0;                                !- Airflow Permeability

WindowProperty:ShadingControl,
  Zone 3 Shade,                    !- Name
  InteriorShade,                   !- Shading Type
  ,                                !- Construction with Shading Name
  OnIfHighSolarOnWindow,          !- Shading Control Type
  ,                                !- Schedule Name
  400,                             !- Setpoint {W/m2, W or deg C}
  No,                              !- Shading Control Is Scheduled
  No,                              !- Glare Control Is Active
  MEDIUM REFLECT - MEDIUM TRANS SHADE, !- Shading Device Mater
  FixedSlatAngle,                  !- Type of Slat Angle Control for Bl
  ;                                !- Slat Angle Schedule Name

```

```

Material,
  R13LAYER-DARK,      !- Name
  Rough,              !- Roughness
  0.0889,              !- Thickness {m}
  0.039000001,        !- Conductivity {W/m-K}
  48,                 !- Density {kg/m3}
  1381,               !- Specific Heat {J/kg-K}
  0.9000000,          !- Thermal Absorptance
  0.7500000,          !- Solar Absorptance
  1;                  !- Visible Absorptance

Construction,
  R13WALL-DARK,       !- Name
  R13LAYER-DARK;      !- Outside Layer

```

Modified objects:

```

BuildingSurface:Detailed,
  Zone 4-North Wall,  !- Name
  Wall,               !- Surface Type
  R13WALL-DARK,       !- Construction Name
  Zone 4,             !- Zone Name
. . .

```

```

BuildingSurface:Detailed,
  Zone 4-East Wall,   !- Name
  Wall,               !- Surface Type
  R13WALL-DARK,       !- Construction Name
  Zone 4,             !- Zone Name
. . .

```

```

BuildingSurface:Detailed,
  Zone 4-South Wall,  !- Name
  Wall,               !- Surface Type
  R13WALL-DARK,       !- Construction Name
  Zone 4,             !- Zone Name
. . .

```

```

BuildingSurface:Detailed,
  Zone 4-West Wall,   !- Name
  Wall,               !- Surface Type
  R13WALL-DARK,       !- Construction Name
  Zone 4,             !- Zone Name
. . .

```

```

BuildingSurface:Detailed,
  Zone 4-Roof,        !- Name
  Roof,               !- Surface Type
  R13WALL-DARK,       !- Construction Name
  Zone 4,             !- Zone Name
. . .

```

```

BuildingSurface:Detailed,
  Zone 4-Floor,       !- Name
  Floor,              !- Surface Type
  R13WALL-DARK,       !- Construction Name
  Zone 4,             !- Zone Name
. . .

```

```

FenestrationSurface:Detailed,
  Zone 3-South Window,      !- Name
  Window,                  !- Surface Type
  Double-Pane LowE,        !- Construction Name
  Zone 3-South Wall,       !- Building Surface Name
  ,                        !- Outside Boundary Condition Object
  0.5,                     !- View Factor to Ground
  Zone 3 Shade,            !- Shading Control Name
. . .

```

Exercise Daylighting 1F

```

Output:IlluminanceMap,
  Zone 1 Daylight Map,     !- Name
  Zone 1,                  !- Zone Name
  0,                       !- Z height {m}
  0,                       !- X Minimum Coordinate {m}
  5,                       !- X Maximum Coordinate {m}
  10,                      !- Number of X Grid Points
  0,                       !- Y Minimum Coordinate {m}
  10,                      !- Y Maximum Coordinate {m}
  10;                      !- Number of Y Grid Points

```