Pedestrian, Bike, or Object Entering a Headlight Beam

This module in I.DRR is designed for several different analysis types.

1. To offer the user results from measuring the headlight beam of vehicles with similar headlight bulbs. This information will allow the user to determine the time from when the object entered the headlight beam up until the point the driver began to skid or steer (the perception-response time from when the pedestrian, bike or object entered the highlight beam).
2. Performing time and distance analysis if the user is investigating a pedestrian or bicycle crash
3. Headlight beam analysis only

In this section of I.DRR, the user may enter the vehicle speed and pre-impact maneuvers, as well as the headlight type and the worksheet will calculate the maximum illumination distance and the response time.

INPUT:

Check Metric if measurements are in metric units [a]

If the user is performing an analysis to determine when the bike, pedestrian or object first enters the headlight beam pattern, leave “Check for Headlight Beam ONLY”, unchecked [b]. This will display the path of the pedestrian relative to the vehicle (blue line).

Note: when an object and vehicle is on a collision course, the eccentricity angle does not change.

If the user is performing a “Headlight Beam Analysis Only”, check “Check for Headlight Beam ONLY” [b]. Figure 1 displays the “Headlight Beam Analysis Only” analysis display.
Both worksheets will allow the user to enter the vehicle speed \([L]\), pre-impact maneuvers \([m]\) and headlight type \([q]\). I.DRR will then calculate the maximum illumination distance and response time \([u]\).

**INPUT:**
**Intruder Travel Dist (Di) [h]** - the distance that the pedestrian travels from the point the pedestrian landed his past foot off the road to the pedestrian’s position at impact.

Example: The pedestrian was standing on the side of the road and then crosses two traffic lanes and is struck in the middle of the third lane the pedestrian is crossing. Each lane is 12 feet across, assuming no shoulder.

The user would enter 31.5 feet ([2.5 lanes x 12 feet] + 1.5 ft). 1.5 feet represents the value of the distance the pedestrian was from the road edge. No driver response study measured a response time from a position earlier than near the road edge. If applying a driver response time, the analysis cannot start from a position earlier than 1.5 feet (0.5m) from the road edge. If the pedestrian was running or if the pedestrian was emerging from behind an obstacle, the same starting point is still utilized but the resulting response is likely to be faster.

**Intruder Speed (IS) [i]** - the speed of the pedestrian, bicycle or object (mph or km/h)

**Crossing Direction [j]** - the angle at which the object or pedestrian was crossing the road

Example: The pedestrian was crossing the road at a 45 degree angle to their right and was struck by a vehicle on the right side.

The user would select “Crossing 135 degrees (Toward)”.  
Example: The pedestrian was crossing the road at a 45 degree angle to their left and was struck by a vehicle on the left side.

The user would select “Crossing 45 degrees Away”

**Crossing Time (CT) [k]** - the time for the object or pedestrian to travel the distance the user entered.  This value is calculated by I.DRR, by the equation:

\[ CT = \frac{Di}{IS} \]

Where:
- \(Di\) is the Intruder Travel Distance
- \(IS\) is intruder speed

**Vehicle Speed [L]** - the speed of the vehicle, in mph or km/h

**Pre-Impact steer/ Decel Distance [m]** - the distance the vehicle skidded, steered or responded before impact

**Vehicle Deceleration Factor (Gs) [n]** - the average deceleration factor during the maneuver.  This value can be as low as 0.01 if there is coasting deceleration only (during a steer only response) or up to full friction of the traveled surface.

**Grade [o]** - The rate grade

Example: The driver travels down 2 feet for ever 100 feet, the user would enter -0.02.  If the road has an incline of 6 feet in a distance of 48 feet, enter 0.125

**LF Corner to Veh Imp Loc [p]** - enter the location the pedestrian or object made contact with the vehicle. All measurements were made form the left front corner of the vehicle (0,0).

Example: A pedestrian was struck by the exact center of a vehicle 6 feet wide. The user would then enter 3.  A pedestrian was struck by the right corner of a 6 foot wide vehicle, the user would enter 6.

**Headlight Type [q]** - The user is given the option for selecting headlight type as well as headlight configuration.
Percentile [r]- the percentile the user selects is the percentile of the headlight beam pattern. Headlight beam patterns are measured in such a way to include an equal number of old, new, clean and dirty headlights. I.DRR offers the percentile distance at two foot (0.6m) intervals. The results are shown graphically in the figure and numerically in the columns of data to the right. The user has the option of selecting a 5th to the 95th percentile headlight beam pattern. The results are calculated as follows:

All measurements are conducted on asphalt surfaces.

Light meter readings were taken with NIST certified light meters. Light meters were calibrated immediately before the measurements were taken. Light meter readings were taken from vehicles as-is. This is an important factor because a goal of this program is to offer an understanding of the range of headlights that are available to the driving public.

Example: The user selects 25th percentile headlight. The distance the headlight will shine from a vehicle that is worse than 75% of all similar type vehicle headlight systems.

Veh Pre-Impact Maneuver Time (t_{vpi}) [s]- the time it took the driver to travel the pre-impact distance at the entered speed and deceleration rate. This is calculated by I.DRR

Distance Traveled by Vehicle After Pedestrian Intrusion-[t] the distance a vehicle will travel at the entered speed and if responding as entered, given the time the object is moving into the road (Crossing Time) or the time to travel the distance illuminated by the headlights (if “headlight beam only” is selected.)

Perception-Response Time (PRT) [u]- PRT is calculated by taking the time the vehicle traveled within the distance at the headlight illuminated the object and subtracting the pre-impact maneuver time. The result is the delay or the perception-response time.

\[
PRT (\text{Headlights}) = \frac{HD}{V} - t_{vpi}
\]

Where:

- HD is Headlight Distance
- V is the velocity of the vehicle
- \( t_{vpi} \) is the Vehicle Pre-impact Maneuver Time

Illumination Level [v]- all original measurements are taken at 0.3 foot candles (3.2 lux) distance. The user has the option to estimate how the illumination will influence the beam pattern by selecting a different illumination from the menu. The estimated distances at other illumination levels are being done by using Inverse Power Law and would assume the headlight beam is uniform at various distances, which it is not.

Headlt Beam [w] the distance the headlight illuminated to the selected level of light at each 2 foot increment. Illuminance measurements are taken at 24 inches from ground level and are measured using a Total Station (surveyors) equipment.

Object Path [x] - the distance the intruding object or pedestrian is from the vehicle when at the location left or right. If any cells are highlighted, it means the object or pedestrian is within the headlight beam at that time and distance [bb].

Distance L/R [y]- the distance the intruding object or pedestrian is from the vehicle when at the location left or right

Time [z]- the time before impact. The highlighted portions are the moments that the object, bicyclist, or pedestrian entered in the road.
The Pedestrian Entered the Headlight Beam

This is calculated by comparing the pedestrian or object’s path with the headlight beam selected. The blue line represents a ratio of the pedestrian or object’s velocity relative to the vehicle’s velocity.

Example: A pedestrian is traveling 5 feet per second and the vehicle is traveling 82.6 feet per second. The pedestrian is crossing left to right relative to the driver. The slope of the blue line would be 5/82.6, or -0.0605. The pedestrian entered the road when 330.8 feet away from the vehicle (see distance traveled by vehicle). The line ends at the location the pedestrian struck the car (LF corner to Veh Imp Loc).

Several iterations are made to determine the point at which the linear trajectory of the pedestrian or object crosses the poly-line that is the headlight beam. The distance at which the two intersect is offered as well as the variance between the next closest iterations. Thus +/- figure is not the accuracy of this method. It is the only accuracy if these exact entries are exact. To obtain a better understanding of uncertainty, the user should also examine how the results will change if the percentile headlight beam is changed.