From the AACT Knowledge Base

Math for stage lighting

The following is a collection of math formulas that can prove useful to lighting designers and electricians.

Power:
Watts = Volts * Amps
Amps = Watts / Volts

Sine Wave (VAC):
RMS Volts = 0.707 x Peak Volts
RMS Volts = 1.11 x Average Volts
Peak Volts = 1.57 x Average Volts
Peak Volts = 1.414 x RMS Volts
Average Volts = 0.637 x Peak Volts
Average Volts = 0.9 x RMS Volts

DC voltage drop of conductor (cable) of L length
V = voltage drop, I = current
R = resistance of conductor per 1000 feet
L = length of conductor in feet
R for 18awg = 6.51, 16awg = 4.09, 14awg = 2.58
12awg = 1.62, 10awg = 1.02, 8awg = 0.64

V = I * L * (R / 1000) * 1.004

Unit Conversions:
inches = millimeters / 25.4
millimeters = inches * 25.4
feet = meters / 0.3048
meters = feet * 0.3048

footcandles = lux / 10.8
lux = footcandles * 10.8

Centigrade = 0.556 * (Fahrenheit - 32)
Fahrenheit = 1.8 * (Centigrade + 32)

pounds = kilograms * 2.205
kilograms = pounds * 0.454

degrees = 180 * radians / PI
radians = PI * degrees /180

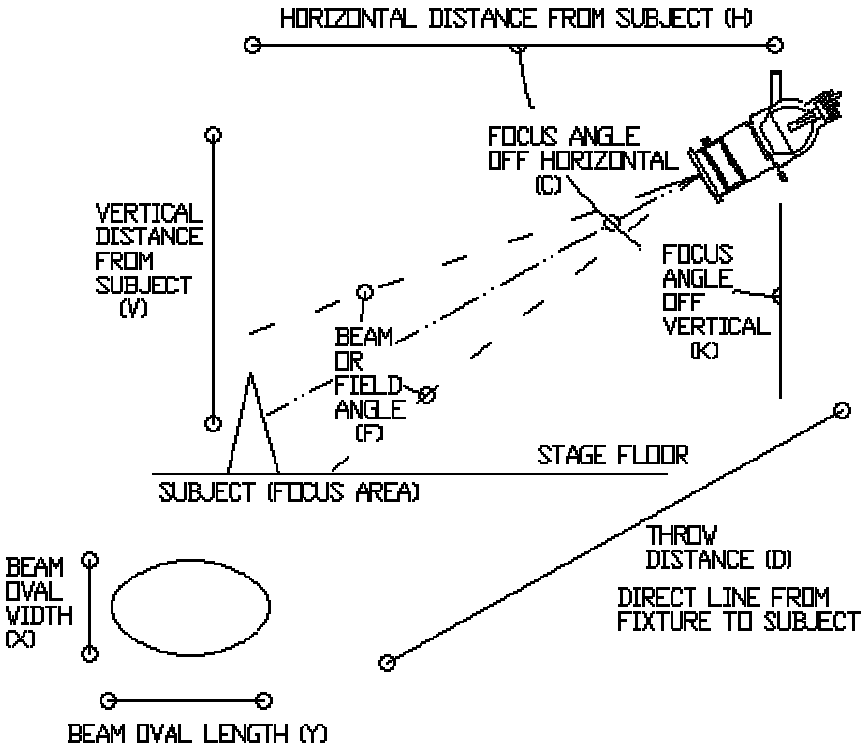
Pattern projection magnification and required pattern size:
A = new pattern size, B = old pattern size,
C = new projection size, D = old projection size
P = projection magnification

for standard AQ61 (or Altman 360Q) ellipsoidals, consider old pattern size to be 3" (size of gate), and old projection size to be the beam spread using the field angle information. Check diameter of gate (shutter plane opening) for other fixtures.

A = B * (C/D)
P = D / B

Distances, intensities, spreads, and angles:

As seen in the drawing to the right:
D = throw distance, V = vertical height, H = horizontal distance,
C = focus angle off horizontal, K = focus angle off vertical,
F = beam or field angle of fixture
X = beam spread (beam oval width), Y = beam oval length
mf = beam spread multiplying factor



footcandles:
Footcandles = Candlepower / (D * D)

candlepower:
Candlepower = Footcandles * (D * D)

beam angle multiplying factor (mf):
mf = 2 * TAN(F / 2)
mf = X / D

beam angle (F):
F = 2 * ATAN(mf / 2)
F = 2 * ATAN(X / (2 * D))

beam spread *(oval width X if not straight on)*:
X = D * (2 * TAN(F / 2))
X = D * mf

beam oval length (Y) ***(when beam hits surface at angle)*****:**
Y = V * (TAN(K + F/2) - TAN(K - F/2))

throw distance (D):
D = X / mf
D = SQUARE ROOT((V * V) + (H * H))
D = H / COS(C)
D = V / SIN(C)
D = H / SIN(K)
D = V / COS(K)
D = SQUARE ROOT(Candlepower / Footcandles)

horizontal distance (H):
H = SQUARE ROOT((D * D) - (V * V))
H = V / TAN(C)
H = D * COS(C)
H = D * SIN(K)
H = V * TAN(K)

vertical height (V):
V = SQUARE ROOT((D * D) - (H * H))
V = H * TAN(C)
V = D * SIN(C)
V = D * COS(K)
V = H / TAN(K)

focus angle off horizontal (C):
C = ATAN(V / H)
C = ASIN(V / D)
C = 90 - ASIN(H / D)
C = 90 - K

focus angle off vertical (K):
K = ATAN(H / V)
K = ASIN(H / D)
K = 90 - ASIN(V / D)
K = 90 - C