Veh Wt:	2930.00
Pass Wt:	230.00
Hood Ht:	25.00
Ped Wt:	33.00
Ped Ht:	62.00
Ped F:	0.54
1. Ped C/M:	36.50
1. Ped AirD:	26.50
1. Ped Throw:	30.50
1. Ped Slide:	4.00
1. 1st Evid:	6.50
1. Braking?:	Y
1. Imp - VFrt:	30.00
1. VC Speed:	30.60
1. VC Mu:	0.78
1. VC Dist:	41.20
1. Pre-Skid:	11.20
1. Radar (Braking):	31.00
1. Radar (Impact):	
2. Ped C/M:	39.00
2. Ped AirD:	20.25
2. Ped Throw:	27.58
2. Ped Slide:	7.33
2. 1st Evid:	3.75
2. Braking?:	Y
2. Imp - VFrt:	23.50
2. VC Speed:	29.10
2. VC Mu:	0.78
2. VC Dist:	36.90
2. Pre-Skid:	13.40
2. Radar (Braking):	30.00
2. Radar (Impact):	
3. Ped C/M:	39.00
3. Ped AirD:	27.60
3. Ped Throw:	36.30
3. Ped Slide:	8.70
3. 1st Evid:	12.00
3. Braking?:	Y
3. Imp - VFrt:	26.00
3. VC Speed:	31.80
3. VC Mu:	0.75
3. VC Dist:	45.20
3. Pre-Skid:	19.20
3. Radar (Braking):	32.00
3. Radar (Impact):	
4. Ped C/M:	38.00
4. Ped AirD:	30.10
4. Ped Throw:	39.60
4. Ped Slide:	9.50

Sand Bag Tests:		
Bag Wt:	28 lb	
# Tests:	10	
Results:	20	16
	19	17
	18	16
	17	17
	17	
	16	
Totals:	173	
Avg:	17.30	
Ped F:	0.62	

4. 1st Evid:	-1.70
4. Braking?:	Y
4. Imp - VFrt:	27.50
4. VC Speed:	30.00
4. VC Mu:	0.78
4. VC Dist:	38.50
4. Pre-Skid:	11.00
4. Radar (Braking):	30.00
4. Radar (Impact):	
5. Ped C/M:	38.00
5. Ped AirD:	40.60
5. Ped Throw:	57.00
5. Ped Slide:	16.40
5. 1st Evid:	6.10
5. Braking?:	Y
5. Imp - VFrt:	41.50
5. VC Speed:	35.80
5. VC Mu:	0.78
5. VC Dist:	55.40
5. Pre-Skid:	13.90
5. Radar (Braking):	37.00
5. Radar (Impact):	
6. Ped C/M:	37.00
6. Ped AirD:	53.20
6. Ped Throw:	78.10
6. Ped Slide:	24.90
6. 1st Evid:	2.00
6. Braking?:	N
6. Imp - VFrt:	0.00
6. VC Speed:	0.00
6. VC Mu:	0.00
6. VC Dist:	0.00
6. Pre-Skid:	0.00
6. Radar (Braking):	0.00
6. Radar (Impact):	46.00
7. Ped C/M:	36.00
7. Ped AirD:	31.80
7. Ped Throw:	45.20
7. Ped Slide:	13.40
7. 1st Evid:	10.70
7. Braking?:	Y
7. Imp - VFrt:	39.00
7. VC Speed:	37.80
7. VC Mu:	0.74
7. VC Dist:	62.80
7. Pre-Skid:	23.80
7. Radar (Braking):	38.00
7. Radar (Impact):	
8. Ped C/M:	36.00

8. Ped AirD:	39.20
8. Ped Throw:	61.00
8. Ped Slide:	21.80
8. 1st Evid:	0.00
8. Braking?:	Y
8. Imp - VFrt:	46.50
8. VC Speed:	37.00
8. VC Mu:	0.72
8. VC Dist:	62.90
8. Pre-Skid:	16.40
8. Radar (Braking):	37.00
8. Radar (Impact):	
9. Ped C/M:	
9. Ped AirD:	
9. Ped Throw:	
9. Ped Slide:	0.00
9. 1st Evid:	
9. Braking?:	
9. Imp - VFrt:	
9. VC Speed:	
9. VC Mu:	
9. VC Dist:	
9. Pre-Skid:	0.00
9. Radar (Braking):	
9. Radar (Impact):	
10. Ped C/M:	
10. Ped AirD:	
10. Ped Throw:	
10. Ped Slide:	0.00
10. 1st Evid:	
10. Braking?:	
10. Imp - VFrt:	
10. VC Speed:	
10. VC Mu:	
10. VC Dist:	
10. Pre-Skid:	0.00
10. Radar (Braking):	
10. Radar (Impact):	

Pedestrian/Bicycle Crash Analysis

Instructors: Tony Becker / Mike Reade

Date: 26-May-10

Place: Sewell, NJ

Vehicle: 1998 Plymouth Breeze
VIN: 1P3EJ46C2WN109504
OL: 186 inches
OW: 71 inches
WB: 108 inches
FOH: 36 inches
ROH: 42 inches
Weight: 3,160.00 lb
Hood H: 27 inches

Searle (Angle):

$$V = \frac{\sqrt{2 \times \mu \times g \times d}}{\left[\cos\theta + (\mu \times \sin\theta)\right]}$$

Searle (Mass & Carry):

$$V_{min} = \frac{M+m}{M}\sqrt{\frac{2\mu g(d - Carry)}{1+\mu^2}}$$

Searle Maximim:

$$V_{max} = \sqrt{2 \times \mu \times g \times d}$$

Searle Minimum:

$$V_{min} = \sqrt{\frac{2 \times \mu \times g \times d}{1+\mu^2}}$$

Crash Data:	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
Ped Ht (in.):	62	62	62	62	62	62	62	62		
Ped C/M Ht (in.):	36.5	39	39	38	38	37	36	36		
Ped Slide D (ft.):	4	7.33	8.7	9.5	16.4	24.9	13.4	21.8		
Airborne D (ft.):	26.5	20.25	27.6	30.1	40.6	53.2	31.8	39.2		
Ped f-Value:	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54		
Throw D (ft.):	30.5	27.58	36.3	39.6	57	78.1	45.2	61		
Takeoff (Min):	10	10	10	10	10	10	10	10		
Takeoff (Max.):	20	20	20	20	20	20	20	20		
1st Evid. (ft):	6.5	3.8	12.0	-1.7	6.1	2.0	10.7	0.0		
Ped Weight (lb):	33	33	33	33	33	33	33	33		
Vehicle Data:										
Hood Height (in.):	25	25	25	25	25	25	25	25		
C/M - Hood Change (in.):	12	14	14	13	13	12	11	11		
Braking (Yes=Y/No=N):	Y	Y	Y	Y	Y	N	Y	Y		
Skid Total (ft.):	41.2	36.9	45.2	38.5	55.4		62.8	62.9		
Skid Impact (ft.):	11.2	13.4	19.2	11	13.9		23.8	16.4		
Road f-Value:	0.78	0.78	0.75	0.78	0.78		0.74	0.72		
Vericom (Impact):	25.97	23.09	24.07	25.35	30.93		30.01	31.86		
Radar (Start Braking):	31.0	30.0	32.0	30.0	37.0		38.0	37.0		
Radar (Impact):						46.0				

Pedestrian/Bicycle Crash Analysis

Instructors: Tony Becker / Mike Reade

Test 1

Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	20.61	mph
Searle (20 Degree) Takeoff:	19.77	mph
Searle Minimum Formula:	**19.56**	mph
Searle Maximum Formula:	22.23	mph

Vehicle Speed Analysis:

Speed - Start of Braking (Skid):	31.05	mph
Speed - Impact (Skid):	25.97	mph
Speed - Start of Braking (Radar):	31.00	mph
Speed - Impact (Radar):	N/A	mph
Speed - Impact (Vericom):	25.97	mph

Other Calculations:

Speed (With Adjusted Data):	20.06	mph
Throw Minus Carry Distance(ft):	28.20	feet
Location of First Evidence (ft.):	6.5	feet
% of Speed Attained (Ped):	75%	
Difference (C/M vs. Hood H (in.):	11.5	inches
Takeoff From Video (Degrees):	8	Degrees
Carry Distance (ft.):	2.30	feet

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	3,160.00	lb
Pedestrian Weight: (m)	33	lb
Ped C/M Height: (H)	3.04	feet

Searle Minimum Analysis: (1993, 2009)

$$V_{min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

= **19.02 mph**

Searle Minimum Analysis: (2009)

$$V_{min} = \frac{M + m}{M}\sqrt{\frac{2\mu g(d - Carry)}{1 + \mu^2}}$$

= **19.00 mph**

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

Pedestrian/Bicycle Crash Analysis

Instructors: Tony Becker / Mike Reade

Test 2

Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	19.60	mph
Searle (20 Degree) Takeoff:	18.80	mph
Searle Minimum Formula:	**18.60**	mph
Searle Maximum Formula:	21.14	mph

Vehicle Speed Analysis:

Speed - Start of Braking (Skid):	29.38	mph
Speed - Impact (Skid):	23.09	mph
Speed - Start of Braking (Radar):	30.00	mph
Speed - Impact (Radar):	N/A	mph
Speed - Impact (Vericom):	23.09	mph

Other Calculations:

Speed (With Adjusted Data):	19.14	mph
Throw Minus Carry Distance(ft):	25.68	feet
Location of First Evidence (ft.):	3.8	feet
% of Speed Attained (Ped):	81%	
Difference (C/M vs. Hood H (in.):	14.0	inches
Takeoff From Video (Degrees):	8	Degrees
Carry Distance (ft.):	1.90	feet

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	3,160.00	lb
Pedestrian Weight: (m)	33	lb
Ped C/M Height: (H)	3.25	feet

Searle Minimum Analysis: (1993, 2009)

$$V_{min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

= **18.00 mph**

Searle Minimum Analysis: (2009)

$$V_{min} = \frac{M + m}{M}\sqrt{\frac{2\mu g(d - Carry)}{1 + \mu^2}}$$

= **18.13 mph**

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

Pedestrian/Bicycle Crash Analysis

Instructors: Tony Becker / Mike Reade

Test 3

Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	22.48	mph
Searle (20 Degree) Takeoff:	21.57	mph
Searle Minimum Formula:	**21.34**	mph
Searle Maximum Formula:	24.25	mph

Vehicle Speed Analysis:

Speed - Start of Braking (Skid):	31.89	mph
Speed - Impact (Skid):	24.07	mph
Speed - Start of Braking (Radar):	32.00	mph
Speed - Impact (Radar):	N/A	mph
Speed - Impact (Vericom):	24.07	mph

Other Calculations:

Speed (With Adjusted Data):	22.16	mph
Throw Minus Carry Distance(ft):	33.00	feet
Location of First Evidence (ft.):	12.0	feet
% of Speed Attained (Ped):	89%	
Difference (C/M vs. Hood H (in.):	14.0	inches
Takeoff From Video (Degrees):	5	Degrees
Carry Distance (ft.):	3.30	feet

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	3,160.00	lb
Pedestrian Weight: (m)	33	lb
Ped C/M Height: (H)	3.25	feet

Searle Minimum Analysis: (1993, 2009)

$$V_{min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

= **20.82 mph**

Searle Minimum Analysis: (2009)

$$V_{min} = \frac{M + m}{M}\sqrt{\frac{2\mu g(d - Carry)}{1 + \mu^2}}$$

= **20.56 mph**

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

Pedestrian/Bicycle Crash Analysis

Instructors: Tony Becker / Mike Reade

Test 4

Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	23.48	mph
Searle (20 Degree) Takeoff:	22.53	mph
Searle Minimum Formula:	22.29	mph
Searle Maximum Formula:	25.33	mph

Vehicle Speed Analysis:

Speed - Start of Braking (Skid):	30.01	mph
Speed - Impact (Skid):	25.35	mph
Speed - Start of Braking (Radar):	30.00	mph
Speed - Impact (Radar):	N/A	mph
Speed - Impact (Vericom):	25.35	mph

Other Calculations:

Speed (With Adjusted Data):	23.40	mph
Throw Minus Carry Distance(ft):	36.80	feet
Location of First Evidence (ft.):	-1.7	feet
% of Speed Attained (Ped):	88%	
Difference (C/M vs. Hood H (in.):	13.0	inches
Takeoff From Video (Degrees):	5	Degrees
Carry Distance (ft.):	2.80	feet

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	3,160.00	lb
Pedestrian Weight: (m)	33	lb
Ped C/M Height: (H)	3.17	feet

Searle Minimum Analysis: (1993, 2009)

$$V_{min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

= 21.80 mph

Searle Minimum Analysis: (2009)

$$V_{min} = \frac{M + m}{M}\sqrt{\frac{2\mu g(d - Carry)}{1 + \mu^2}}$$

= 21.71 mph

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

Pedestrian/Bicycle Crash Analysis

Instructors: Tony Becker / Mike Reade

Test 5

Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	28.17	mph
Searle (20 Degree) Takeoff:	27.03	mph
Searle Minimum Formula:	**26.74**	mph
Searle Maximum Formula:	30.39	mph

Vehicle Speed Analysis:

Speed - Start of Braking (Skid):	36.00	mph
Speed - Impact (Skid):	30.93	mph
Speed - Start of Braking (Radar):	37.00	mph
Speed - Impact (Radar):	N/A	mph
Speed - Impact (Vericom):	30.93	mph

Other Calculations:

Speed (With Adjusted Data):	28.14	mph
Throw Minus Carry Distance(ft):	53.20	feet
Location of First Evidence (ft.):	6.1	feet
% of Speed Attained (Ped):	86%	
Difference (C/M vs. Hood H (in.):	13.0	inches
Takeoff From Video (Degrees):	5	Degrees
Carry Distance (ft.):	3.80	feet

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	3,160.00	lb
Pedestrian Weight: (m)	33	lb
Ped C/M Height: (H)	3.17	feet

Searle Minimum Analysis: (1993, 2009)

$$V_{min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

= **26.33 mph**

Searle Minimum Analysis: (2009)

$$V_{min} = \frac{M + m}{M}\sqrt{\frac{2\mu g(d - Carry)}{1 + \mu^2}}$$

= **26.10 mph**

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

Pedestrian/Bicycle Crash Analysis

Instructors: Tony Becker / Mike Reade

Test 6

Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	32.98	mph
Searle (20 Degree) Takeoff:	31.64	mph
Searle Minimum Formula:	**31.30**	mph
Searle Maximum Formula:	35.57	mph

Vehicle Speed Analysis:

Speed - Start of Braking (Skid):	N/A	mph
Speed - Impact (Skid):	N/A	mph
Speed - Start of Braking (Radar):	N/A	mph
Speed - Impact (Radar):	46.00	mph
Speed - Impact (Vericom):	N/A	mph

Other Calculations:

Speed (With Adjusted Data):	32.65	mph
Throw Minus Carry Distance(ft):	74.70	feet
Location of First Evidence (ft.):	2.0	feet
% of Speed Attained (Ped):	68%	
Difference (C/M vs. Hood H (in.):	12.0	inches
Takeoff From Video (Degrees):	8	Degrees
Carry Distance (ft.):	3.40	feet

NEW Searle Formulae Analysis:

Vehicle Weight: (M)	3,160.00	lb
Pedestrian Weight: (m)	33	lb
Ped C/M Height: (H)	3.08	feet

Searle Minimum Analysis: (1993, 2009)

$$V_{min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

= **30.96 mph**

Searle Minimum Analysis: (2009)

$$V_{min} = \frac{M + m}{M}\sqrt{\frac{2\mu g(d - Carry)}{1 + \mu^2}}$$

= **30.93 mph**

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

Pedestrian/Bicycle Crash Analysis

Instructors: Tony Becker / Mike Reade

Test 7

Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	25.09	mph
Searle (20 Degree) Takeoff:	24.07	mph
Searle Minimum Formula:	**23.81**	mph
Searle Maximum Formula:	27.06	mph

Vehicle Speed Analysis:

Speed - Start of Braking (Skid):	37.34	mph
Speed - Impact (Skid):	30.01	mph
Speed - Start of Braking (Radar):	38.00	mph
Speed - Impact (Radar):	N/A	mph
Speed - Impact (Vericom):	30.01	mph

Other Calculations:

Speed (With Adjusted Data):	24.30	mph
Throw Minus Carry Distance(ft):	42.90	feet
Location of First Evidence (ft.):	10.7	feet
% of Speed Attained (Ped):	79%	
Difference (C/M vs. Hood H (in.):	36.0	inches
Takeoff From Video (Degrees):	11	Degrees
Carry Distance (ft.):	2.30	feet

NEW Searle Formulae Analysis:

Van Weight: (M)	3,160.00	lb
Pedestrian Weight: (m)	33	lb
Ped C/M Height: (H)	3.00	feet

Searle Minimum Analysis: (1993, 2009)

$$V_{min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

= **23.38 mph**

Searle Minimum Analysis: (2009)

$$V_{min} = \frac{M + m}{M}\sqrt{\frac{2\mu g(d - Carry)}{1 + \mu^2}}$$

= **23.44 mph**

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

Pedestrian/Bicycle Crash Analysis

Instructors: Tony Becker / Mike Reade

Test 8

Searle Analysis: (1983)

Searle (10 Degree) Takeoff:	29.15	mph
Searle (20 Degree) Takeoff:	27.96	mph
Searle Minimum Formula:	27.66	mph
Searle Maximum Formula:	31.44	mph

Vehicle Speed Analysis:

Speed - Start of Braking (Skid):	36.86	mph
Speed - Impact (Skid):	31.86	mph
Speed - Start of Braking (Radar):	37.00	mph
Speed - Impact (Radar):	N/A	mph
Speed - Impact (Vericom):	31.86	mph

Other Calculations:

Speed (With Adjusted Data):	29.08	mph
Throw Minus Carry Distance(ft):	56.80	feet
Location of First Evidence (ft.):	0.0	feet
% of Speed Attained (Ped):	87%	
Difference (C/M vs. Hood H (in.):	36.0	inches
Takeoff From Video (Degrees):	5	Degrees
Carry Distance (ft.):	4.20	feet

NEW Searle Formulae Analysis:

Van Weight: (M)	3,160.00	lb
Pedestrian Weight: (m)	33	lb
Ped C/M Height: (H)	3.00	feet

Searle Minimum Analysis: (1993, 2009)

$$V_{min} = \sqrt{\frac{2\mu g(d - \mu H)}{1 + \mu^2}}$$

= 27.29 mph

Searle Minimum Analysis: (2009)

$$V_{min} = \frac{M + m}{M}\sqrt{\frac{2\mu g(d - Carry)}{1 + \mu^2}}$$

= 26.97 mph

(Percentage is determined by dividing Searle Minimum result by Vehicle Impact Speed)

Pedestrian/Bicycle Crash Analysis

Instructors: Tony Becker / Mike Reade

At the 2009 IPTM Special Problems conference in Orlanda, Florida, Dr. John Searle presented an updated paper on pedestrian investigations entitled: **"The appplication of throw distance formulae."** This paper discusses several topics such as: Measurement of coefficient of friction, Sandbag coefficient of friction on different surfaces, Field and crash test studies, Semi empirical methods, Throw distance formulae, Comparison of throw equations with field data, Application of the throw distance formulae to individual cases, Alternative approach, Future work, Conclusions. Additionally, this papers discusses several F.A.Q. in the application of the throw distance formulae, the Protocol for the measurement of coefficient of friction, the Derivation of the throw distance formulae and the Layout of example calculation, the calculation of vehicle speed from pedestrian throw distance. The formula below determines the amount of horizontal speed loss after the pedestrian has been projected into the air from a height above the ground. The loss of speed in "feet per second" is added to the results of the pedestrian's slide to stop action along the road surface.

Searle (Horizontal Speed Loss on Landing - 2009):

$$\text{Horizontal Speed Loss on Landing} = \mu \sqrt{V_y^2 + 2gH}$$

Where:

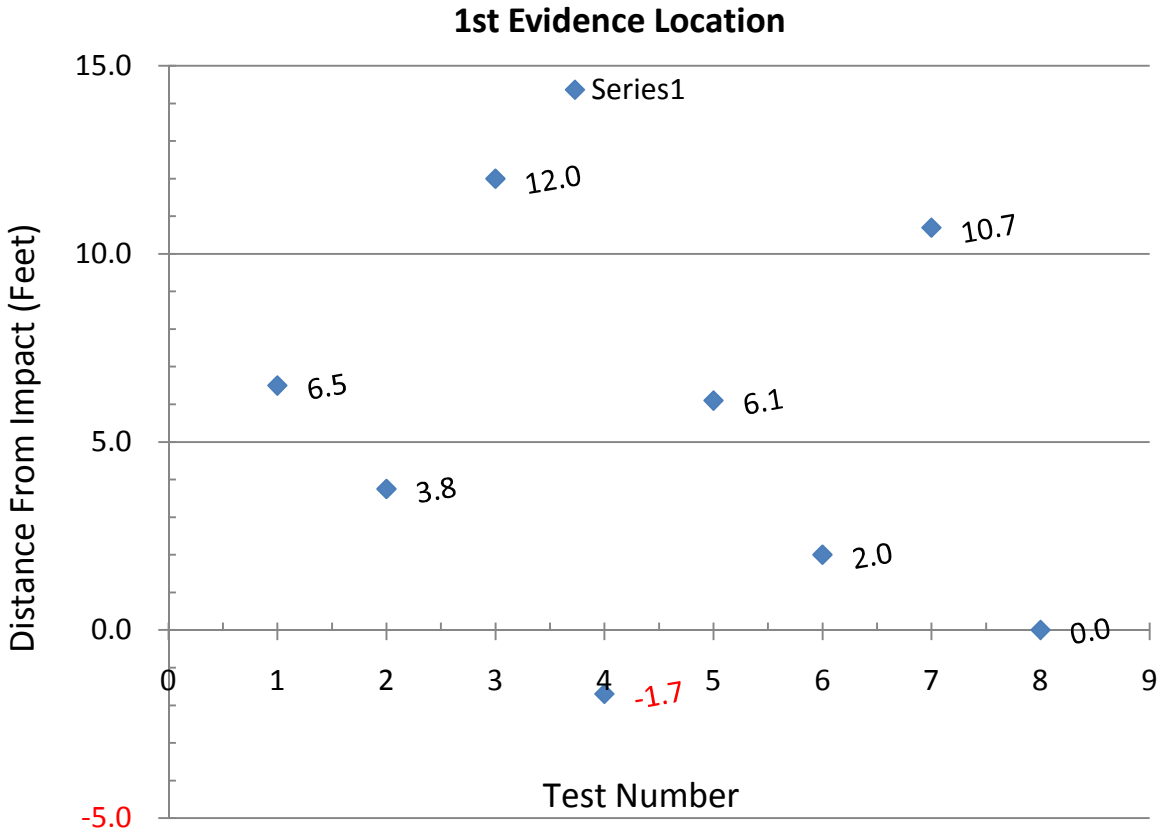
- μ = Pedestrian Sliding Friction
- V_y = Original Vertical Velocity
- g = Gravity (32.2 f/s/s)
- H = Height Pedestrian Projected From
- θ = Takeoff Angle (degrees)

DATA	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
Impact Speed (mph):	25.97	23.09	24.07	25.35	30.93	46.00	30.01	31.86		
Ped Slide Distance:	4.00	7.33	8.70	9.50	16.40	24.90	13.40	21.80		
Ped Sliding μ:	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54		
Projectile Takeoff θ:	8.00	8.00	5.00	5.00	5.00	8.00	11.00	5.00		
Original Vertical Vel:	28.09	22.22	9.46	10.50	15.63	88.16	70.52	16.58		
Ped C/M Height (ft).:	3.04	3.25	3.25	3.17	3.17	3.08	3.00	3.00		
Ped Slide Speed:	11.79	15.97	17.39	18.18	23.88	29.43	21.59	27.53		
Speed Loss (Landing):	8.08	8.22	7.99	7.91	8.00	9.14	8.77	7.82		
Searle Totals (fps):	19.88	24.18	25.38	26.08	31.88	38.57	30.36	35.36		
Impact Velocity (fps):	38.08	33.87	35.30	37.18	45.36	67.46	44.01	46.72		
Difference (fps):	-18.21	-9.68	-9.92	-11.09	-13.47	-28.89	-13.65	-11.36		
Difference (mph):	-12.41	-6.60	-6.76	-7.56	-9.19	-19.70	-9.31	-7.75		

Negative values under-estimate the vehicle's impact speed

Pedestrian/Bicycle Crash Analysis

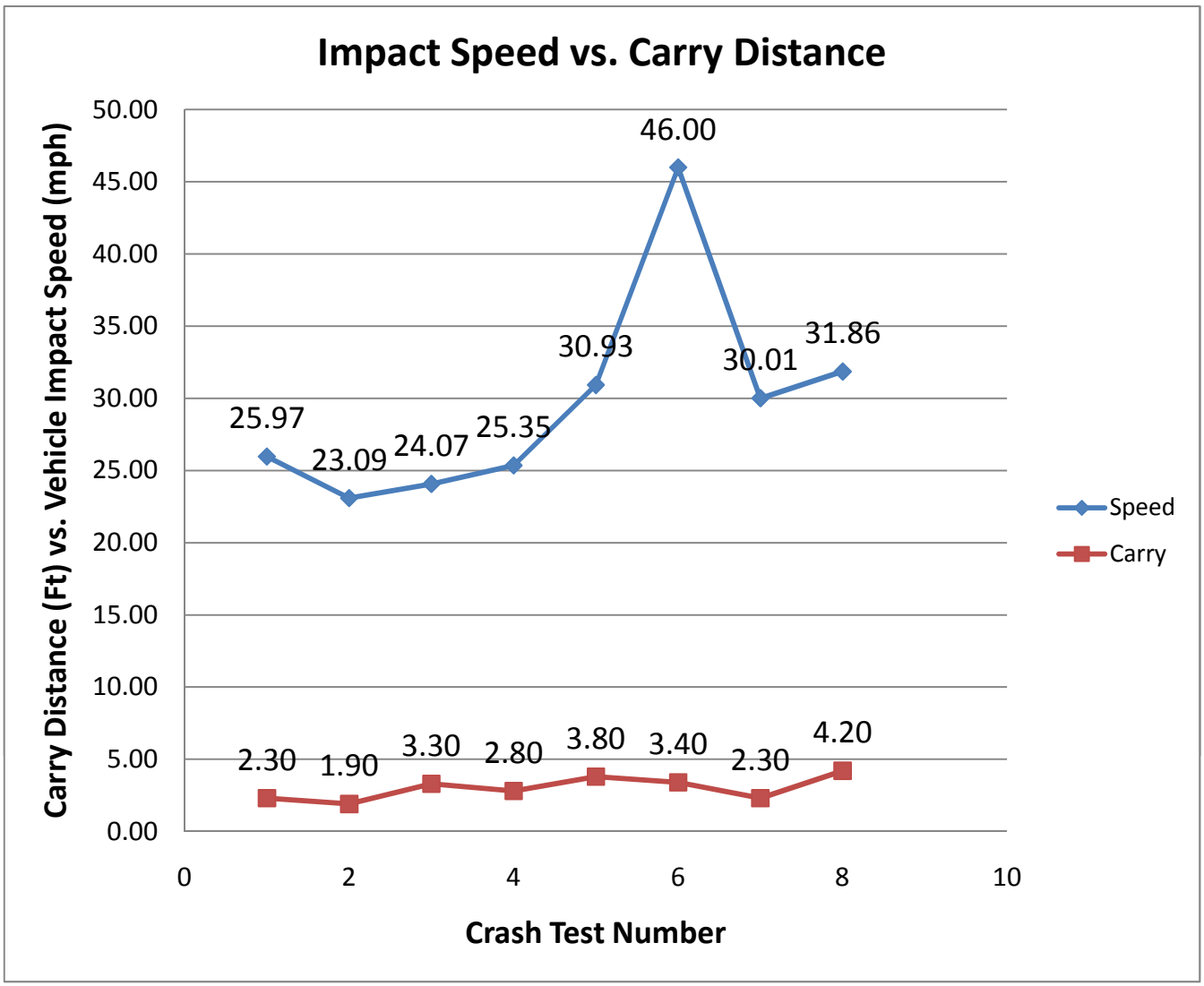
Instructors: Tony Becker / Mike Reade



The above graph represents the location of the "1st" Evidence after impact. The longitudinal distance was measured from the impact location either forward or backward. In cases where the 1st Evidence lands before impact, the value is shown as a "RED" negative number.

Pedestrian/Bicycle Crash Analysis

Instructors: Tony Becker / Mike Reade



Data	Speed	Carry
Test 1:	25.97	2.30
Test 2:	23.09	1.90
Test 3:	24.07	3.30
Test 4:	25.35	2.80
Test 5:	30.93	3.80
Test 6:	46.00	3.40
Test 7:	30.01	2.30
Test 8:	31.86	4.20
Test 9:		
Test 10:		
	Average:	**3.00**