1) 25 feet is 7.6 m.

From here, just use the formula:

\[ x = v_0^2 \frac{\sin(2\theta)}{g} \]

\[ 7.6 = 12^2 \frac{\sin(2\theta)}{9.8} \]

\[ 0.5 = \sin(2\theta) \]

\[ \sin^{-1} 0.5 = 2\theta \]

\[ \theta = \frac{\sin^{-1} 0.5}{2} \]

\[ = 15^\circ \]

2) To find the time its in the air, we’ll use

\[ y = y_0 + v_{y0}t - \frac{1}{2} gt^2 \]

This will require us to find the y-component of the initial velocity, which is

\[ v_0 \sin \theta = 15 \sin 42 = 10 \text{ m/s} \]. Thus,

\[ 0 = 2.5 + 10t - \frac{1}{2} (9.8)t^2 \]

Solving this requires the quadratic formula, which you don’t really need to know. It gives:

\[ t = -0.22 \]

\[ \text{and:} \]

\[ t = 2.26 \]

Clearly, time should be positive, so we’ll use the second one. Now, to find the distance it travelled, we need the x-component of velocity,

\[ v_0 \cos \theta = 15 \cos 42 = 11.1 \text{ m/s} \].

From here it’s simply,

\[ x = x_0 + v_{x0}t \]

\[ x = 0 + 11.1 \cdot 2.26 \]

\[ = 16.7 \text{ m} \]
3) This is vector addition. The first vector is easy, let's call it \( \mathbf{A} \), it has \( A_x = 0 \) and \( A_y = 30 \) yards. The second one has components \( B_x = 5 \cos 20 = 4.7 \) yards, and \( B_y = -5 \sin 20 = 1.7 \) yards. Notice the minus sign on \( B_y \)—I had to put it in by hand, because the second vector points downward. If we call his displacement \( \mathbf{C} = \mathbf{A} + \mathbf{B} \), then

\[
C_x = A_x + B_x = 4.7 \\
C_y = A_y + B_y = 30 - 1.7 = 28.3
\]

And the length of \( \mathbf{C} \) (the displacement) is

\[
C = \sqrt{C_x^2 + C_y^2} \\
= \sqrt{4.7^2 + 28.3^2} \\
= 28.7 \text{ yd}
\]

4) We can find force from \( F = ma \), as long as we can get \( a \). That comes from:

\[
v^2 = v_0^2 + 2a(s - s_0) \\
(2 m/s)^2 = 0 + 2a(2m) \\
a = 1 m/s^2
\]

Hence, \( F_{\text{tot}} = m_{\text{tot}} a = (65 kg + 40 kg)(1 m/s^2) = 105 N \)

5) Weight is always just another name for gravitational force, which is always \( F_g = mg \). It’s just that sometimes \( g \) changes. So on this strange planet,

\[
300 N = m(7.8 m/s^2) \\
m = 38.5 kg
\]

On earth, we can give his weight either as \( F_g = mg = (38.5 kg)(9.8 m/s^2) = 377 N \), or as \( 38.5 kg \frac{2.2 lbs}{kg} = 84.6 lbs \). As you can see, he’s a scrawny little fella. But you’ve seen what aliens look like, lanky guys with big heads. Or at least that’s what I see on FOX.

6) His acceleration is \( a = \Delta v / \Delta t = (4 m/s)/(1 s) = 4 m/s^2 \)

The acceleration down a ramp is \( a = g \sin \theta - \mu_k \cos \theta \), but we’re ignoring friction so it’s just \( a = g \sin \theta \). Setting these equal gives

\[
4 = 9.8 \sin \theta \\
\sin \theta = \frac{4}{9.8} \\
\theta = \sin^{-1}(4/9.8) = 24^\circ
\]
7) We can use conservation of momentum since this is a collision problem. Bettis has mass 114.3 kg, and the safety has only 95 kg. Initially, the total momentum (use “B” for Bettis, “S” for the safety)

\[ P_0 = m_B v_{B0} + m_S v_{S0} \]

\[ = (114.3)(8.5) + (95)v_{S0} \]

Of course, the safety’s goal is to make sure that after the collision, the two of them (stuck together) have 0 velocity, and hence zero momentum. So we have:

\[(114.3)(8.5) + (95)v_{S0} = 0\]

\[ v_{S0} = -10.3 m/s \]

Since this is an Usain Bolt kind of speed, I somehow doubt the safety was able to make the stop.

8) Rafael Nadal, perhaps the greatest “clay court” tennis player of all time, is running to the right during a match at 2.4 m/s when he decides he needs to come to a stop. However, part of what makes playing on clay difficult is that players don’t stop right away, they slide. Suppose Rafa (mass 187 lbs) plants his feet but slides a full meter before coming to a stop. What must be the coefficient of friction between clay and tennis shoes?

The reason Rafa comes to a stop is because of a friction force causing a deceleration. The size of this deceleration can be found from

\[ v^2 = v_0^2 + 2a(s - s_0) \]

\[ 0 = (2.4 m/s)^2 + 2a(1m) \]

\[ a = -2.9 m/s^2 \]

Hence, by \( F_{fr} = ma_{fr} \) the friction force must have been \((84.8 kg)(-2.9 m/s^2) = 246 N\)

On the other hand, we also know that \( F_{fr} = \mu_k N = \mu_k mg \), or

\[ F_{fr} = \mu_k (84.8)(9.8) \]

\[ = \mu_k 831 \]

Since these have to be equal, we have

\[ \mu_k 831 = 246 N \]

\[ \mu_k = 0.29 \]

Protip: As you might have noticed, you actually don’t need his mass to do this. Could you have figured it out if I hadn’t told you?