Worksheet 7-1 Uniform Circular Motion

Assume that the car in *Figure 1* is moving at a constant speed.

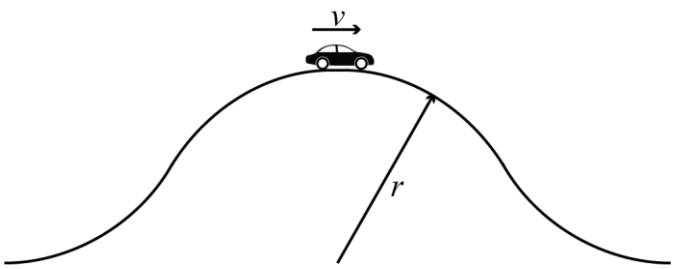


Figure 1

1. Construct a qualitative motion map of the car in *Figure 1*.
2. Is the car experiencing an acceleration? If yes, in what direction is the acceleration? Explain how you know.
3. Construct a qualitative force diagram for the car when it's at the top of the hill. Justify the relative forces in your force diagram.
4. Suppose the speed of the car is 11.1 m/s (≈ 25 mph) and the radius of curvature is 25 m. Determine the magnitude of the centripetal acceleration of the car.
5. If the mass of the car is 1200 kg, what $\Sigma\mathbf{F}$ would be required to cause this centripetal acceleration?
6. Construct a quantitative force diagram for the car.
7. At what speed would the centripetal force equal the force of gravity?
8. Suppose the car were going faster than the speed that you calculated for question 7. Describe what would happen to the car.

Assume that the car in *Figure 2* is moving at a constant speed.

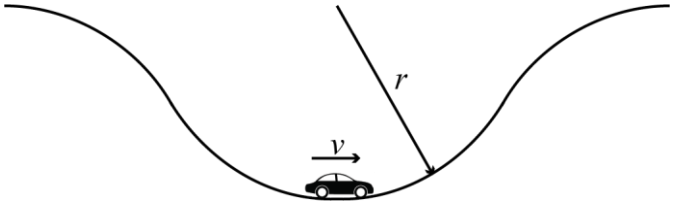
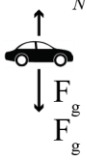
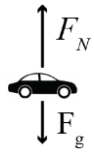


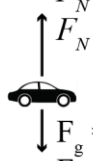
Figure 2

9. Construct a qualitative motion map of the car in *Figure 2*.
10. In what direction is the car experiencing an acceleration? Explain how you know.
11. Construct a qualitative force diagram for the car when it's at the bottom of the hill. Justify the relative forces in your force diagram.
12. Suppose the speed of the car in *Figure 2* is 11.1 m/s and the radius of curvature is 25 m. Determine the magnitude of the centripetal acceleration of the car.
13. If the car's mass is 1200 kg, what $\Sigma\mathbf{F}$ would be required to cause this centripetal acceleration?
14. Now, construct a quantitative force diagram for the car.
15. If the driver of the car weighs 540 N, what is the magnitude of the upward force that the seat exerts on the driver?

1. The dots will be close together at the higher points and farther apart at the lower ones.
2. The car is accelerating down toward the center of the circle. Any object in uniform circular motion is acceleration toward the center of the circle.
3. 

Since the net force points to the center of the circle, the downward force must be greater than the upward force.
4. $$a = \frac{v^2}{r}$$ $$a = \frac{(11.1\ \text{m/s})^2}{25\ \text{m}}$$ $$a = \boxed{4.9\ \text{m/s}^2}$$
5. $$\Sigma F = ma$$ $$\Sigma F = (1200\ \text{kg})(4.9\ \text{m/s}^2)$$ $$\Sigma F = \boxed{5900\ \text{N}}$$
6. $$F_N = F_g - F_c$$ $$F_N = 11760\ \text{N} - 5900\ \text{N}$$ $$F_N = 5860\ \text{N}$$


7. $$a = \frac{v^2}{r}$$ $$v = \sqrt{ar}$$ $$v = \sqrt{(9.8\ \text{m/s}^2)(25\ \text{m})}$$ $$v = \boxed{15.7\ \text{m/s}}$$
8. At speeds greater than 15.7 m/s the car will not remain in contact with the ground.
9. The dots will be close together at the higher points and farther apart at the lower ones.
10. The car is accelerating up toward the center of the circle. Any object in uniform circular motion is acceleration toward the center of the circle.
11. 

12. $$a = \frac{v^2}{r}$$ $$a = \frac{(11.1\ \text{m/s})^2}{25\ \text{m}}$$ $$a = \boxed{4.9\ \text{m/s}^2}$$
13. $$\Sigma F = ma$$ $$\Sigma F = (1200\ \text{kg})(4.9\ \text{m/s}^2)$$ $$\Sigma F = \boxed{5900\ \text{N}}$$
14. $$F_N = F_g + F_c$$ $$F_N = 11760\ \text{N} + 5900\ \text{N}$$ $$F_N = 17660\ \text{N}$$


15. $$\Sigma F = F_N - F_g$$ $$F_N = \Sigma F + F_g$$ $$F_N = ma + F_g$$ $$F_N = (55.1\ \text{kg})(4.9\ \text{m/s}^2) + 540\ \text{N}$$ $$F_N = \boxed{812\ \text{N}}$$