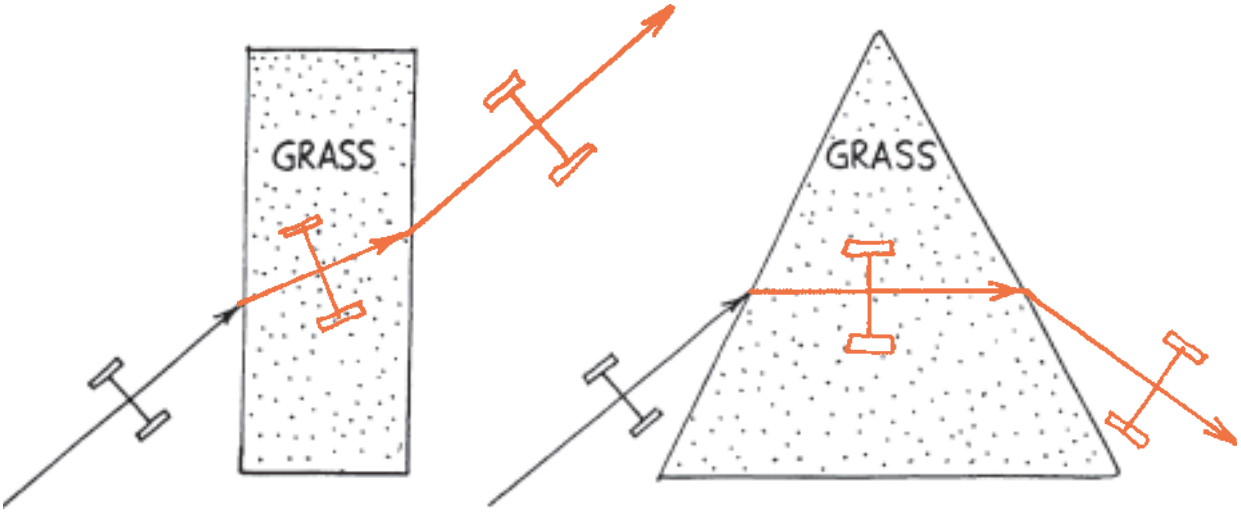
Name _____ Class _____ Date _____

Concept-Development Practice Page **29-3**

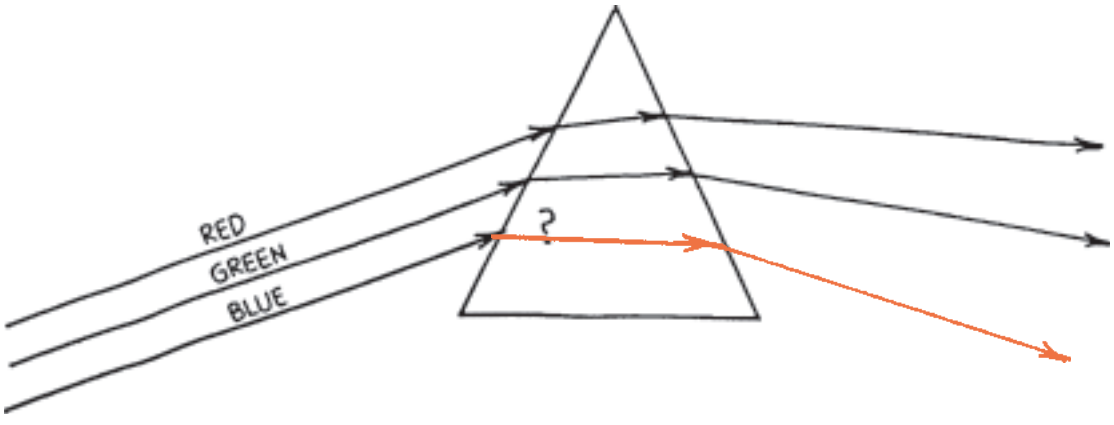
Refraction

1. A pair of toy cart wheels that can spin independently are rolled obliquely from a smooth surface onto two plots of grass — a rectangular plot as shown at the left, and a triangular plot as shown at the right. The ground is on a slight incline so that after slowing down in the grass, the wheels speed up again when emerging on the smooth surface. Finish each sketch and show some positions of the wheels inside the plots and on the other side. Clearly indicate their paths and directions of travel.



(Relate the change in direction of the wheels to that of light when it changes speed.)

2. Red, green, and blue rays of light are incident upon a glass prism as shown. The average speed of red light in the glass is less than in air, so the red ray is refracted. When it emerges into the air it regains its original speed and travels in the direction shown. Green light takes longer to get through the glass. Because of its slower speed it is refracted as shown. Blue light travels even slower in glass. Complete the diagram by estimating the path of the blue ray.



(The blue ray bends more than green both in the glass and when it emerges.)

CONCEPTUAL PHYSICS

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3. The sketch shows that due to refraction, the man sees the fish closer to the water surface than it actually is.

   a. Draw a ray beginning at the fish's eye to show the line of sight of the fish when it looks upward at 50° to the normal at the water surface. Draw the direction of the ray after it meets the surface of the water and continues in the air.

   b. At the 50° angle, does the fish see the man, or does it see the reflected view of the starfish at the bottom of the pond? Explain.

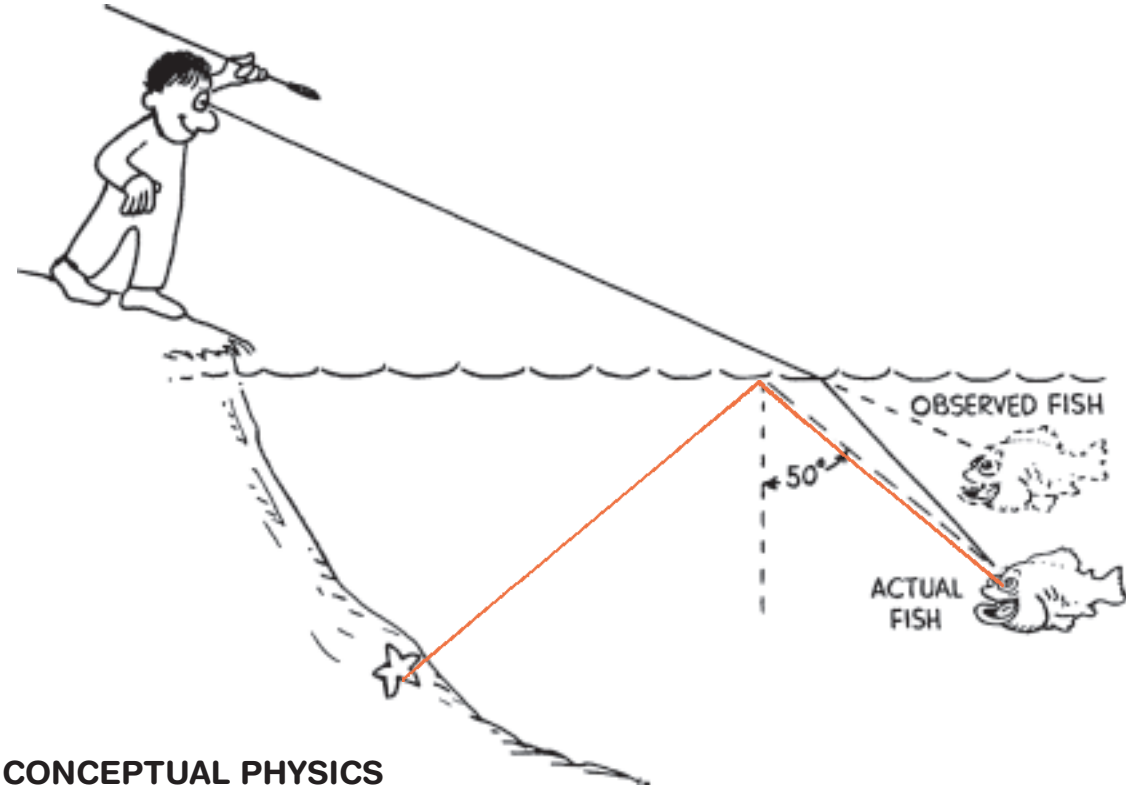
   The fish sees the reflected view of the starfish (since 50° is beyond the critical angle of 48°, so there is total internal reflection).

   c. To see the man, should the fish look higher or lower than the 50° path?

   Higher, so the line of sight to the water is less than 48° with the normal.

   d. If the fish's eye were barely above the water surface, it would see the world above in a 180° view, horizon to horizon. The fisheye view of the world above as seen beneath the water, however, is very different. Due to the 48° critical angle of water, the fish sees a normally 180° horizon-to-horizon view compressed within an angle of 96°.

   A 180° view from horizon to zenith (90°) and back down to horizon is compressed into a 96° cone, where 96° is twice the critical angle of 48°. This compression of an image is copied by the fisheye lenses designed for cameras. Interestingly enough, the lens of the fish's eye does not work like the fisheye lenses of cameras. The compression of images of objects in air seen underwater by the fish is caused by refraction at the air-water boundary, not by the design of the lens of its eye.



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