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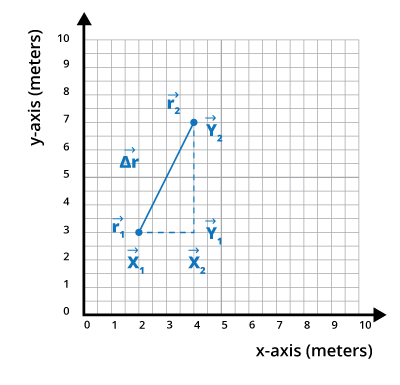
PHY 115—Spring 2014

03/3/2014

Assignment 4

1. An object is moving in a plane, and is initially at position 𝑟⃗1 = (2.0m, 3.0 m). The object then moves 2.0 m in the x-direction and 4.0 m in the y-direction.

a. Sketch the total displacement (∆𝑟⃗) of the object in the xy plane. The axes must be the x-axis and the y-axis.

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b. Express the total displacement in terms of its magnitude and the angle it makes with the positive x-axis.

**Δ Xx** = Xx2 – Xx1 **Δ Xx** = 4.0m – 2.0m **Δ Xx** = 2.0m

**Δ Yy** = Yy2 – Yy1 **Δ Yy** = 7.0m – 3.0m **Δ Yy** = 4.0m

**θ** = tan-1(**Yy** / **Xx**) **θ** = tan-1 (4.0m / 2.0m) **θ** = tan-1(2.0m) **θ** = 63°

**Δ 𝑟⃗** = √(**Xx**2 + **Yy**2)

**Δ 𝑟⃗** = √(2.0m2 + 4.0m2)

**Δ 𝑟⃗** = √(20)

**Δ 𝑟⃗** = 4.5m

**Δ 𝑟⃗** = 4.5m

2. The young A. Doinel has a peculiar job. He works with remote-controlled toy ships, operating them for endless hours. While Doinel is inside an artificial pond, at position (0, 0) and at rest, he watches the motion of the toy ship on the surface of the water. The motion is 2-D. At time t1 = 2.0 s, the position of the boat is r1 = (2.0 m, 3.0 m). At time t2 = 4.0 s, the position of the boat is r2 = (1.0 m, 4.5 m). a. Express the displacement of the ship in terms of the magnitude of the displacement vector and the angle it makes with the positive x-axis.

**ΔXx** = Xx2 – Xx1 **ΔXx** = 1.0m – 2.0m **ΔXx** = -1.0m

**ΔYy** = Yy2 – Yy1 **ΔYy** = 4.5m – 3.0m **ΔYy** = 1.5m

**θ** = tan-1(**Yy** / **Xx**) **θ** = tan-1 (1.5m / -1.0m) **θ** = tan-1(-1.5m) **θ** = -56° or 124°

**Δ 𝑟⃗** = √(**ΔXx**2 + **ΔYy**2)

**Δ 𝑟⃗** = √(-1.0m2 + 1.5m2)

**Δ 𝑟⃗** = √(3.25m)

**Δ 𝑟⃗** = 1.8m

**Δ 𝑟⃗** = 1.8m

b. Calculate the average velocity (direction and magnitude) of the ship, during the time interval between t1 and t2. The direction must be expressed in terms of the angle that the average velocity vector makes with the horizontal axis.

**Δ 𝑟⃗** = 1.8m

**Δt =** t2 – t1 **Δt =** 4s – 2s **Δt =** 2s

**Vav**= (**Δ𝑟⃗**) / (**Δt**) **Vav**= (1.8m / 2s) **Vav**= 0.9m / 1s

**θ** = tan-1(**Yy** / **Xx**) **θ** = tan-1 (1.5m / -1.0m) **θ** = tan-1(-1.5m) **θ** = -56° or 124°

**Vav**= 0.9m / 1s and **θ** = 124°

3. Part of Doinel’s job is to test the ships for impact resistance. Unfortunately, Doinel was not given any sophisticated equipment that would allow him to perform high-quality tests. With well-meaning purposes but atrocious methods for performing the impact resistance tests, Doinel places a toy ship on a flat ground. Doinel uses a small trebuchet to launch the ship at a speed of 20 m/s with an angle of 40 degrees with the positive horizontal axis. The ship travels in a parabolic path and returns to ground level. Neglect air resistance and treat the ship as a particle to answer the following questions.

a. How long does the entire flight last?

**θ** = 40°

**Voy =** V0sinθ **Voy =** (20m/s)(sin(40°)) **Voy =** 13m/s

**Vy =** V0y + gt1/2

**0 =** (13m/s) + (-10m/s2)(t1/2)

t1/2 = 1.3s

t = 2.6s

t = 2.6s

b. What is the maximum vertical displacement of the ship?

**y =** y0 + V0yt + ½(-g)t2

**y =** 0 + (13m/s)(1.3s) + ½(-10m/s2)(1.3s)2

**y =** 8.5m

**y =** 8.5m

c. What is the horizontal range of the toy ship?

**V0x =**  v0cosθ **V0x =**  (20m/s)(cos(40°)) **V0x =**  15m/s

**R =** V0xt2

**R = (**15m/s)(2.6s)

**R =** 39m

**R**= 39m

d. EXTRA-CREDIT: What is the instantaneous velocity vector (in terms of its x and y components) of the ship 1.0 second after it was launched?

**Vavx = Δx / Δt =** 15m/s

**Vavy = Δy / Δt =** 13m/s

**Δ 𝑟⃗** = √(**ΔXx**2 + **ΔYy**2)

**Δ 𝑟⃗** = √(15m/s2 + 13m/s2)

**Δ 𝑟⃗** = 19.8m/s

**Δ 𝑟⃗** = 19.8m/s

4. In a videogame, a skilful warrior launches a cannon ball with an initial speed of 50 m/s, at an angle of 27 degrees with the horizontal axis. The cannon is at a height of 1.5 m from ground level. On its way up, the cannonball hits the head of an enemy soldier who is guarding a tower located at a horizontal distance of 62 m from the cannon. The enemy soldier was at rest at the moment he was hit. To answer the following questions, neglect air resistance and the height of the catapult. Assume that the ground is flat.

a. How much time does the cannonball travel before it hits the enemy soldier?

**V0x =**  v0cosθ **V0x =**  (50m/s)(cos(27°)) **V0x =**  45m/s

**V0y =**  v0sinθ **V0y =**  (50m/s)(sin(27°)) **V0y =**  23m/s

**R =** V0xt

**t =** (62m)/(45m/s)

**R =** 1.4s

**R**= 1.4s

b. At how many meters above the ground is the enemy soldier?

**y =** y0 + V0yt + ½(-g)t2

**y =** (1.5m) + (23m/s)(1.4s) + ½(-10m/s2)(1.4s)2

**y =** 23.9m

**y**= 23.9