Chapter C - Problems

Blinn College - Physics 2425 - Terry Honan

Problem C.1

Two points have cartesian coordinates (3 m, −8 m) and (−5 m, 5 m).

(a) Convert these points to polar coordinates.

(b) What is the distance between these points?

Problem C.2

Two points have polar coordinates $(r, \theta) = (5\text{ m}, 25\,°)$ and $(r, \theta) = (8\text{ m}, 120\,°)$.

(a) Convert these points to cartesian (rectangular) coordinates.
(b) What is the distance between these points?

Problem C.3

A car drives around a traffic circle with a radius of 20 m.
(a) When the car drives half way around the circle, what is the magnitude of the displacement vector and the total distance driven?
(b) When the car drives once around a full circle, what is the magnitude of the displacement vector and the total distance driven?

Problem C.4

(a) Obtain a component expression for a position vector when its magnitude and direction are given by $r = 40\text{ m}$ and $\theta = 155\,°$.
(b) A car moves at 70 mi/hr in the direction 12° south of west. Obtain a component expression for the velocity of the car.
(c) A rope pulls with a force of 40 N in the direction given by $\theta = -75\,°$. Obtain a component expression for the force vector.

Problem C.5

A person walks in successive displacements of 20 m west and then 30 m in the direction 25 ° East of North. What is the person's net displacement?

Problem C.6

Define the vectors $\vec{A}$ and $\vec{B}$ by

$$\vec{A} = \langle 5, -6, 2 \rangle = 5\,\hat{x} - 6\,\hat{y} + 2\,\hat{z} \text{ and}$$
$$\vec{B} = \langle -3, 5, -7 \rangle = -3\,\hat{x} + 5\,\hat{y} - 7\,\hat{z}$$

(a) What is the vector $\vec{C} = \vec{A} + \vec{B}$? Also give the magnitude of $\vec{C}$ and specify its direction by finding $\hat{C}$, a unit vector in the direction of $\vec{C}$.

(b) What is the vector $\vec{D} = \vec{A} - 2\,\vec{B}$? Also give the magnitude of $\vec{D}$ and specify its direction by finding $\hat{D}$, a unit vector in the direction of $\vec{D}$.

Problem C.7

A soccer ball is kicked in four consecutive displacements as shown. What is the resultant displacement of the ball? Also give the magnitude and direction of the resultant.

Problem C.8

A golfer putts a ball toward a hole 5 yards to the north. If his first putt is 6 yards in the direction $15°$ east of north, then what displacement vector is needed for the second putt to hit the hole. Also give the magnitude and direction of the second putt's displacement.

Problem C.9

(a) Show that if the angle between vectors $\vec{A}$ and $\vec{B}$ is θ, then the magnitude of their sum is:

$$\left\|\vec{A} + \vec{B}\right\| = \sqrt{A^2 + B^2 + 2\,A\,B\cos\theta}$$

(Hint: Since this is independent of the choice of coordinates, one can, without loss of generality, choose coordinates so that A is in the x direction.)

(b) The *law of cosines* says that if a triangle has sides of lengths A, B and C, and the angle opposite the side of length C is γ then:

$$C^2 = A^2 + B^2 - 2\,A\,B\cos\gamma$$

Use the result of part (a) to prove this.

Problem C.10

A car drives West at $20\,m/s$ for 5 min, then drives $30\,m/s$ to the North for 2 min and, finally, drive in the direction $30°$ East of South at $40\,m/s$ for 3 min.

(a) What is the net displacement of the car?

(b) What is the average velocity of the car?

(c) What is the average speed of the car?

Problem C.11

The displacement of a body as a function of time in SI units is given by:

$$\vec{r}(t) = \left\langle t^3 + 9\,t - 5,\, 2\,t^4 - 5\,t^2 + 18 \right\rangle.$$

(a) What is the average velocity of the body between 1s and 3s?

(b) What is the speed of the body at 2s?

(c) In what direction is the body moving at 2s?

(d) What is the acceleration at 2s?

Problem C.12

At time zero a particle starts at the origin with a velocity of $\langle 30, -20 \rangle\, m/s$. It moves with a constant acceleration so that after 5 s the velocity is $\langle -20, 10 \rangle\, m/s$.

(a) Obtain expressions for the velocity as a function of time $\vec{v}(t)$ and the position vector as a function of time $\vec{r}(t)$.

(b) What is the speed after 12 s?

Problem C.13

A bartender slides a beer mug to Joe at the end of a bar. Joe, not being at his best, misses the mug which then tragically slides off the bar onto the floor below. Suppose the bar is height h and the mug lands a distance d from the base of the bar.

(a) With what speed did the mug leave the bar?
(b) What was the speed of the mug when it hit the floor?
(c) In what direction was the mug moving when it hit the floor?
(d) What are the answers to parts (a), (b) and (c) when $h = 80$ cm and $d = 1.2$ m?

Problem C.14

An astronaut walking on some new planet finds that with an ititial speed of $3\ \frac{\mathrm{m}}{\mathrm{s}}$ he can jump a maximum distance of 6 m. What is the acceleration due to gravity on this planet?

Problem C.15

A projectile is shot so that its horizontal range is five times its maximum height. What initial angle is needed achieve this? You have enough information to give a numerical answer.

Problem C.16

A football is kicked at a speed of 25 m/s at an angle of 50 ° above horizontal.

(a) What is the maximum height reached by the football?

(b) At t = 2.5 s, what is the displacement, velocity, speed and acceleration of the football?

(c) What is the total horizontal distance the football travels in the air?

(d) Suppose this kick is toward a crossbar that is 3 m high. For the kick to be a *field goal* if must pass over the crossbar. What is the longest field goal (the horizontal distance to the crossbar) that can be made by this kick?

Problem C.17

In making a movie a car drives at a speed of 40 m/s off a 30 m high cliff. How long after leaving the cliff should the sound of the crash be added? Include the time it takes for the sound to return to the top of the cliff. Sound travels at 343 m/s.

Problem C.18

A golfer hits a ball at 40m/s at an angle of 55 ° above horizontal up an inclined fairway with a 10 ° slope. How far up the incline does the ball travel before hitting?

(Hint: Solve of the trajectory (y as a function of x) of the ball and equate that to the equation describing the incline.)

Problem C.19

A car travelling at 100 km/hr is 300 m behind a slower car moving at 80 km/hr. If both cars continue at the same rate how long does it take for the faster car to catch the other?

Problem C.20

A 160 m wide river has a steady current with a uniform speed of 1.5 m/s. A boat crosses this river by maintaining a bearing, the direction in which the boat points, that is perpendicular to the river's flow and with a speed of 2 m/s relative to the water. (a) What is the speed of the boat relative to the shore? (b) How far downstream from the starting point does the boat land?

Problem C.21

The pilot of a plane reads his compass and sees his heading is due south. He also sees that the plane's speed with respect to the air is 200 mi/hr. Suppose there is a 50 mi/hr wind blowing to the west.

(a) What is the velocity of the plane with respect to the ground?

(b) What are the speed and direction of the plane relative to the ground?

Problem C.22

A car moving at a speed v hits a puddle in the road and sprays water. Relative to the car, the spray is shot backward at speed v and at an angle θ above horizontal. What is the velocity of the spray relative to the road? Take the direction of the car's motion to be the x direction and take y to be vertical.