Fall 2021

APPLIED PHYSICS - LAB

Lab-2

- Solutions to Lab-1
- More vectors
- Share/Submit your program

Solutions to Lab-1: (suggested)

1. Using the algebraic form of the Pythagoras theorem, calculate and print the length of the hypotenuse and the angle (between base and hypotenuse) of a triangle using the variables `Hyp` and `theta`. The base and perpendicular of the triangle are given by variables `Bs = 8.3` and `Prp = 4.3`, respectively.

```
GlowScript 3.1 VPython

Bs = 8.3
Prp = 4.3

Hyp = sqrt(Bs**2 + Prp**2)
theta = degrees(atan(Prp/Bs))

print("Hypotenuse = ",Hyp, "units")
print("Angle between hypotenuse and base = ",theta," degrees")
```

```
Hypotenuse =  9.34773 units
Angle between hypotenuse and base =  27.3874  degrees
```

2. Compute the value of the polynomial $y = ax^2+bx+c$ at $x=-2$ using a=1, b=1, c=−6 and print the result on the screen.

```
GlowScript 3.1 VPython

a,b,c = 1,1,-6
x = -2
y = a*(x**2) + b*x + c
print(y)
```

```
-4
```

3. Calculate the sides b and c and the angle α for a triangle with the following information: a = 14.12, β=100°30’, ɣ = 26°.

```
GlowScript 3.1 VPython

a = 14.12                        #units
beta = 100 + 30*0.0166667        #degrees
gamma = 26                       #degrees

alpha = 180-beta-gamma
b = (a/sin(radians(alpha))) * sin(radians(beta))
c = (a/sin(radians(alpha))) * sin(radians(gamma))

print(alpha, "degrees")
print(b, "units")
print(c, "units")
```

```
53.5 degrees
17.2712 units
7.70013 units
```

1. Prove the following vector identities. (Hint: use vectors you made in the above tasks. Print the resulting values to show they are equal (numerical method.))

$$u \times (v \times w) = (u \cdot w)v - (u \cdot v)w$$

$$u \cdot (v \times w) = v \cdot (w \times u) = w \cdot (u \times v)$$

```
GlowScript 3.1 VPython

u = vector(10*random(),10*random(),10*random())
v = vector(10*random(),10*random(),10*random())
w = vector(10*random(),10*random(),10*random())

L = u.cross(v.cross(w))
R = dot(u,w)*v - dot(u,v)*w

print(L)
print(R)
```

```
< 95.7911, -312.023, 239.64 >
< 95.7911, -312.023, 239.64 >
```

2. Find the sum of the following two vectors in unit-vector notation.

   P: 10.0 m, at 25 counterclockwise from +x

   Q: 12.0 m, at 10 counterclockwise from +y

```
GlowScript 3.1 VPython

# 2D vectors
#P: 10.0 m, at 25 counterclockwise from +x
#Q: 12.0 m, at 10 counterclockwise from +y

P_mag = 10            # units
P_ang = 25            # degrees
Q_mag = 12            # units
Q_ang = 10+90         # degrees from +x axis

P = vector(P_mag*cos(radians(P_ang)),P_mag*sin(radians(P_ang)),0)
Q = vector(Q_mag*cos(radians(Q_ang)),Q_mag*sin(radians(Q_ang)),0)
print("vector P = ", P)
print("vector Q = ", Q)
print("P+Q = ", P+Q)
```

```
vector P =  < 9.06308, 4.22618, 0 >
vector Q =  < -2.08378, 11.8177, 0 >
P+Q =  < 6.9793, 16.0439, 0 >
```

More Vectors:

Magnitudes:

We learned in the theory lecture that the magnitude of a 2D vector can be calculated using the Pythagoras theorem, all because it made a right triangle. But we can also extend the Pythagoras theorem to three dimensions.

> **TASK** ↦ Use z^2 inside the radical in Pythagoras theorem and find the magnitude of a 3D vector (A) of your choice. Check if the VPython function `mag( )` gives the same result.
> Hint:

EXAMPLE 8 | Theorem of Pythagoras in R^4

We showed in Example 1 that the vectors

$$\mathbf{u} = (-2, 3, 1, 4) \quad \text{and} \quad \mathbf{v} = (1, 2, 0, -1)$$

are orthogonal. Verify the Theorem of Pythagoras for these vectors.

Solution We leave it for you to confirm that

$$\mathbf{u} + \mathbf{v} = (-1, 5, 1, 3)$$
$$\|\mathbf{u} + \mathbf{v}\|^2 = 36$$
$$\|\mathbf{u}\|^2 + \|\mathbf{v}\|^2 = 30 + 6$$

Thus, $\|\mathbf{u} + \mathbf{v}\|^2 = \|\mathbf{u}\|^2 + \|\mathbf{v}\|^2$

Unit Vectors:

Since every vector has a direction, we can find a unit vector that is pointing in the same direction as your vector A. The x, y, and z are the special directions we represent by vector form (x,0,0), (0,y,0), and (0,0,z), therefore, using the same logic we define unit vectors i, j, and k as (1,0,0), (0,1,0) and (0,0,1) respectively.

> **TASK** ↦ Find the unit vector in the direction of A.

> **TASK** ↦ Create `i_hat`, `j_hat`, and `k_hat` unit vectors. Find the unit vector in the direction of the resultant of the addition of vectors `j_hat` and `k_hat`. Find the magnitude of this resultant vector as well.

> **TASK** ↦ Find the difference of angle between your vector A from earlier tasks and the positive x-axis.

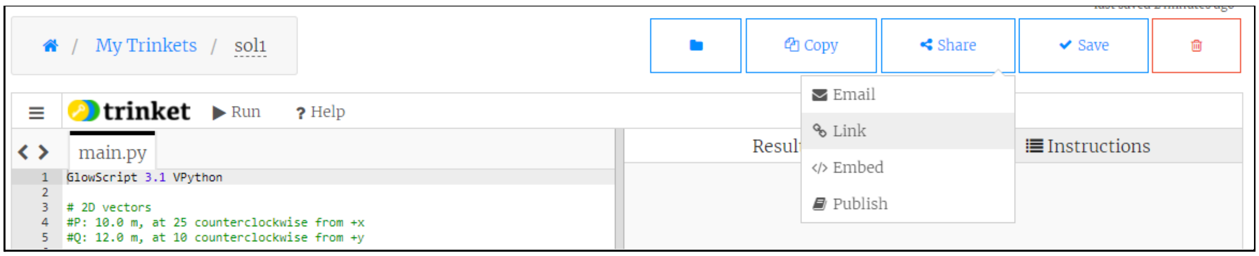
Vector Problems:

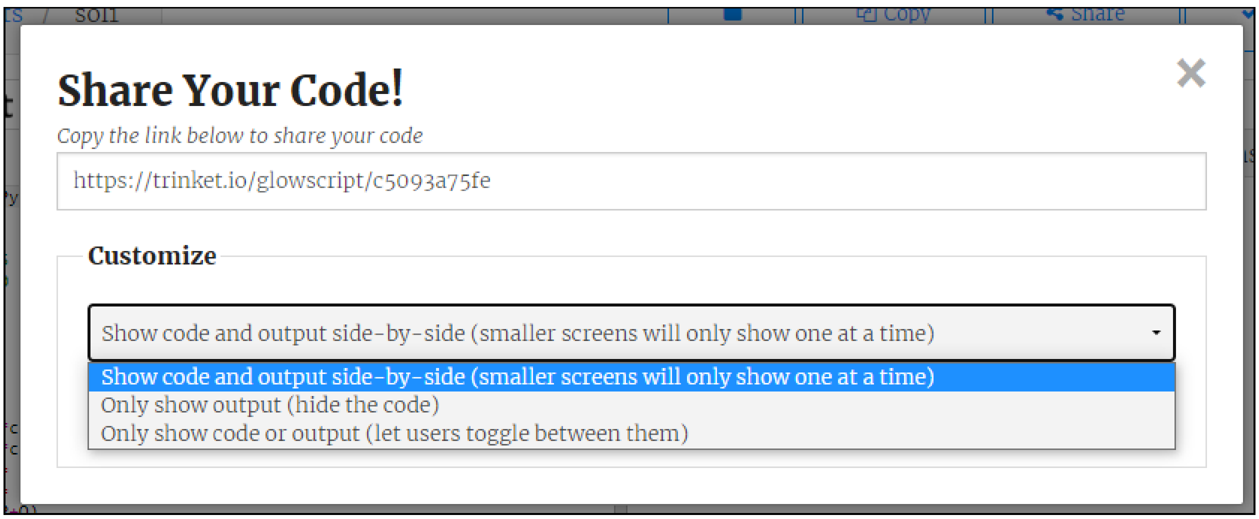
[You will be submitting a single program with answers to all problems below. Make sure the answers are clearly separated.]

1. Find the area of a parallelogram enclosed by the vectors `r = <2.3,3,1.4>` and `s = <3.7,3.1,2.5>`.
2. Generate a new vector `t` on the same plane as `r` and `s`.
3. Find the projection of `t` on `r` and s.
4. Generate a new vector `u` which is 2 units away from `t` in x coordinate, 2.5 units in y, and 1.17 units away in z coordinates.

Share/Submit your program:

When you submit your lab on google classroom, you will need to share your program file in a report (or just the program.) Use the following instructions to generate the link and share it on lab submission on google classroom.





Select the proper option from Customize (first, for homework submissions) and copy the link, and share.