Assignment 6

Exercise A1(Explosion of rotating disk):

- A stationary alien spaceship (no gravity) in the shape of a thin homogeneous disk of radius R, mass M and thickness D rotates with an angular speed ω. Your A-team has infiltrated the alien ship's defenses and has succeeded in implanting a time bomb in the ship's nuclear power generator at the center of the ship.
- At time t=0 the bomb goes off and the ship explodes, after which all ejecta move on the plane of rotation of the alien ship.
- Assume that the energy released by the bomb is E and that all of the bomb's energy is fully transformed into kinetic energy of a very large number N of ejecta of equal size.
- Compute the trajectory in space of any piece of the ejecta at time t>0!
- Scan your solution in a Word document (Deliverable A1).
- Implement the motion and breakup of the alien spaceship in Part A in Unity.

Answer:

The goal of this exercise is to find the trajectory of all ejecta of a rotating, disk shaped spaceship, after an explosion happens in its center and simulate this scenario into Unity. According to the clues we have that the energy from explosion is fully transformed to kinetic energy. Using the formula:

$$\mathbf{K.E. = 1/2\ m\ v^2}$$

we can obtain the speed of ejecta with the codeline:

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ejectaSpeed = Mathf.Sqrt((2.0f * explosionEnergy) /
mass);
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We also have that after the explosion, the rotating disk stops to be rotated and the velocity of the ejecta is transformed from angular to tangential:

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tangential_velocity = angularSpeed * radius;
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But because of the explosion (and assuming that there is no gravity in space), the ejecta don't move only tangentially in one direction, but also in a second direction onto the rotation 2D plane of y axis, defined by x and z axes (considering that the disk only spins around y axis and is perpendicular to that plane). For this reason in the codeline:

finalVelocities[i] = new Vector3(tangential_velocity * Mathf.Sin(angle), 0.0f, tangential_velocity * Mathf.Cos(angle));

in which we set the velocity for each of ejecta. Specifically we set the velocity on y axis to zero and on the x and z axes we set that their velocities is equal to the tangential velocity multiplied by the parametric equation of circle (because the spinning happens at the center of the disk in a "perfect" circle). For this reason in the x axis parameter we multiply the tangential velocity with the sine of the angular displacement of the ejecta and in z axis with the cosine.

One problem that come up into the project is that the angular displacement of the ejecta is normally measured by its rotation around y axis:

angle = ejectaObjects[i].transform.eulerAngles.y;

Because for some reason the above codeline doesn't have the "right" result, all ejecta move into the same direction and the disk doesn't break apart. So we use the following function instead:

angle = Random.Range(0.0f, 360.0f);

that gives a different, random angular displacement for each ejecta and seems to work pretty well. Another final detail we have to take into consideration is the distance of the ejecta that they travel:

distance = Random.Range(0.0f, ejectaSpeed * Time.deltaTime);

Normally all the ejecta travel the same distance, as the explosion is "symmetric" and also have the same mass, but for a more natural result we give random value to each one.