Robotics Study Material

School Level 2

Semester 2

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UNIT – 7

GEARS

CHAPTER-1

INTRODUCTION TO GEARS

Gear is a wheel that has evenly spaced teeth around its circumference or rim and transfers motion from one gear wheel to another gear.
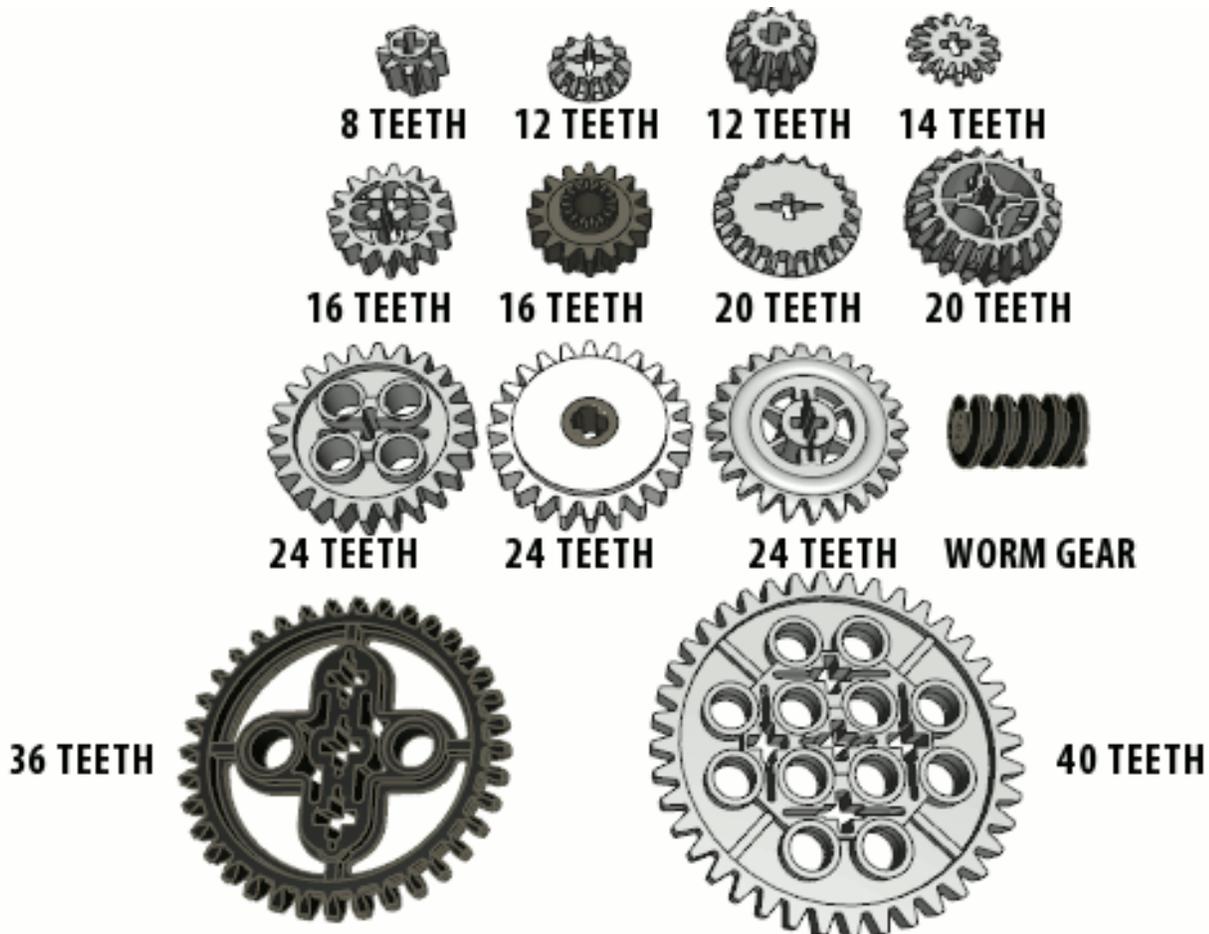
Fig3.1 (i) Different types of gears

Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine. Gears are used for different applications.

Following are the few examples of gears:
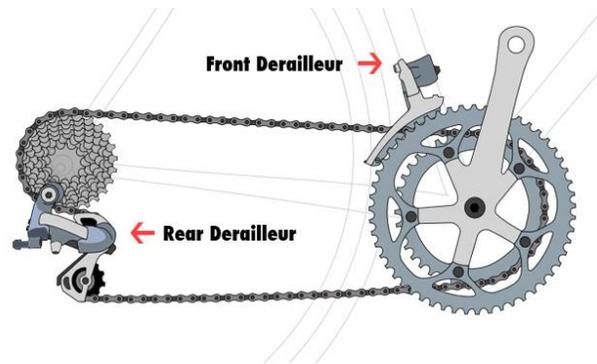
Fig3.1.ii) a) This is the image of the gears in bicycle.
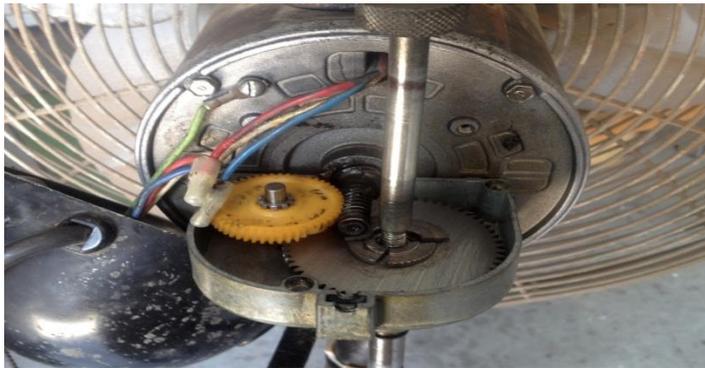
Fig3.1.ii) b) This is the image of oscillating fan showing gear mechanism at the back of the fan.

Fig3.1.ii) c)Gear arrangement in a clock

REASON FOR USING GEARS

There are three reasons for using gears. They are as follows:

1. Change in speed

2. Change in direction

3. Change in torque

    1. Change in speed: Gears can be used to increase or decrease the speed or torque of rotation and can easily be used to reverse the direction of rotation.

   2. Change in direction: Gears are used to transmit rotational motion to a different axis.

    3. Change in torque: Torque can be increased with different gear ratio.

What is torque?

Torque is a force which makes things turn or rotate around an axis. Also, in other words, torque is a measure of how much a force should be acting on an object that will cause that object to rotate. The object rotates about an axis.

Few examples where you can observe torque are:

1. When you twist a bottle lid to open or close it or taps.
2. When you grip and crank a pencil inside a sharpener. Anything with a crank on it works due to torque.
3. When you spin a top by pulling on the thread in a swift motion.
4. When you open / close a door.

<div align="center">TORQUE= FORCE x DISPLACEMENT</div>

Torque is Force x displacement which is why all door knobs / handles are placed at the farthest end from the hinges to maximize the perpendicular distance and minimize the force (effort) for applying a given torque which opens / closes the door

5. When a car accelerates at a certain distance even after applying brakes, it is due to torque applied by the engine.

There are five different types of gears that we will study. They are as follows:

i)   Spur Gear
ii)   Knob Gear
iii)   Crown Gear
iv)   Bevel Gear
v)   Worm Gear

GEAR RATIO:

A Gear Ratio is the number of turns your driving gear must make in order to turn your driven gear once. In other words, the gear ratio is the ratio of the number of turns the output gear makes when the input gear turns once.

$$\text{Gear Ratio} = \frac{\text{Teeth on the driven gear}}{\text{Teeth on the driving gear}}$$

Below is the proper illustration of Driving gear and Driven Gear.
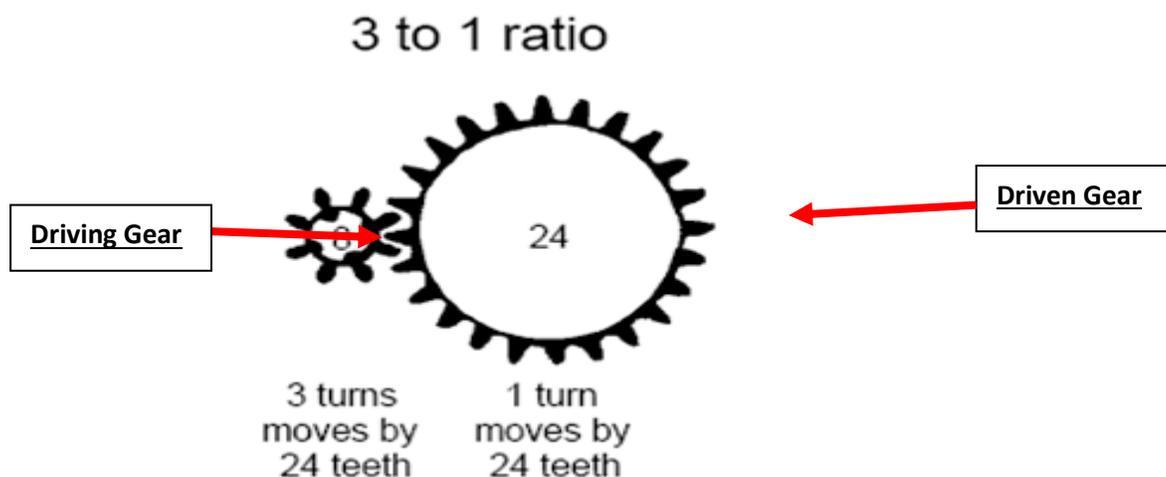
Fig 3.1.iii) The above figure is an example of Gear-Down.

Let us understand in brief the meaning of Gear-Up and Gear-Down.

GEAR-DOWN: A Gear Ratio<1 is called Gear-Down i.e. When the smaller gear moves the larger one, the second gear means the larger one moves slower.

In Fig3.1 iii) when 8 teeth gear moves 3 times then 24 teeth will move 1 time which means a Gear ratio of 3:1. So this means that the speed of gear will decrease. There are many advantage of Gear-Down but one of the most important is high-torque. The less is the Gear-Ratio the more is the torque produced.

GEAR-UP: A Gear Ratio>1 is called Gear-Up i.e. When the larger gear is the driving gear and the smaller one is the driven gear, so the smaller one moves more number of times.

For example: If there is a Gear-Ratio of 1:5. This will indicate that the 40-teeth gear is moving 1 time and so the 8-teeth gear is moving 5 times. Below are the different examples of Gear-Up.

40 Tooth   **40 Tooth**
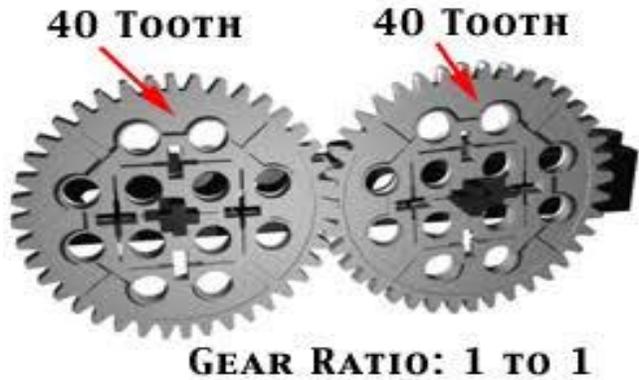
GEAR RATIO: 1 TO 1

(a) Here any can be driving and any can be driven as both have same number of teeth

40 Tooth

8 Tooth

Driving Gear

Driven Gear

GEAR RATIO: 1 TO 5

(b)

40 Tooth

24 Tooth

Driving Gear

Driven Gear
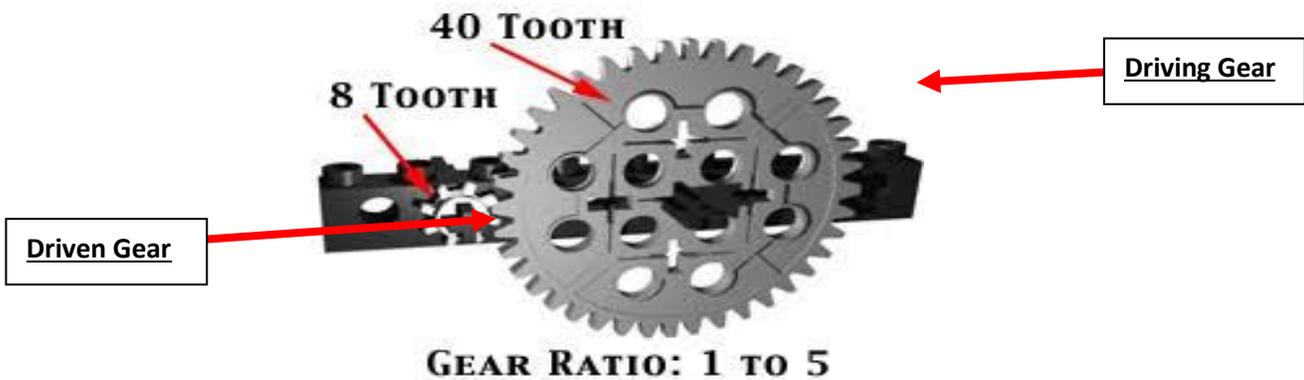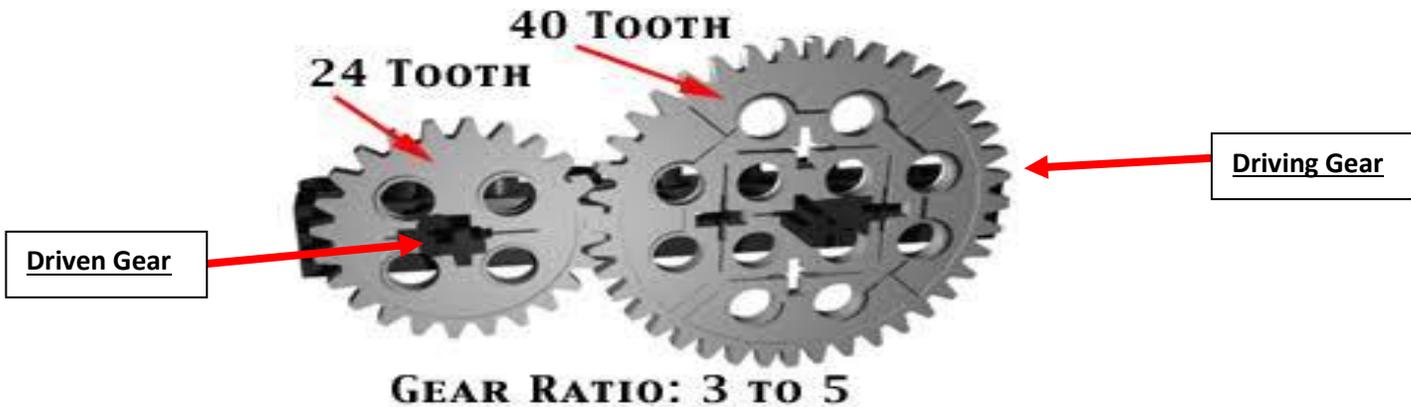
GEAR RATIO: 3 TO 5

(c)

Fig 3.1 iv) All the figures from a) to c) shows different simple gear ratio

Q1. *Fill in the blanks:*

1) ………………………………..are used to transmit power and also to change the speed.
2) The relationship between the speed change is given by ………………………………….
3) The gear which is rotated by handle is called ……………………………..
4) The gear which is rotated because of the rotation of other gear is called …………………………
5) The process in which the speed is increased with the help of the gears is called…………………………

Answers: 1) Gears   3) Driving gear   5) Gear up

      2) Gear ratio   4) Driven gear

Q2. *Multiple Choice Questions:*

1) If 24 tooth gear and 40 tooth gears are messed with each other then what gear ratio will be made by this arrangement

a) 3:1   c) It depends on driving and driven gear

b) 1:3   d) None of these

2) Which example is NOT an example of gear?

a) Bicycle   c) Car

b) Clock   d) None of these

3) What is the name of the force which is used to rotate any object around its axis?

a) Force   c) Torque

b) Pressure   d) Velocity

Answers: 1) c   2) d   3) c

Q3. *Answer the questions:*

1) What is torque? Write the formula for calculation of it.

2) What are the types of gears?

3) Calculate the gear ratio of the followings and also mention the case as gear up or gear down.

Note: 1st gear is the driving gear and last gear is driven gear

    i)   24tooth gear is messed with 8 tooth gear
    ii)   8tooth gear is messed with 40 tooth gear
    iii)   24tooth gear is messed with 40 tooth gear

4) Why gears have tooth on its circumference?

5) What are the uses of gears? Give two real life examples where gears are used.

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CHAPTER-2

SPUR GEARS

SPUR GEAR has teeth that are parallel to axis of gear. This gear pair is used to transmit the power between two parallel shafts.
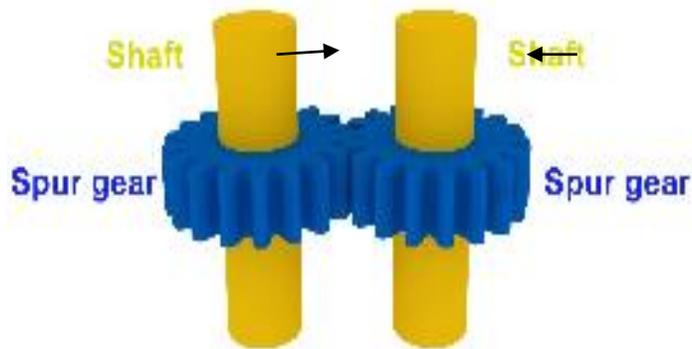

Fig3.2 (i) Figure shows shafts and meshing of spur gear.

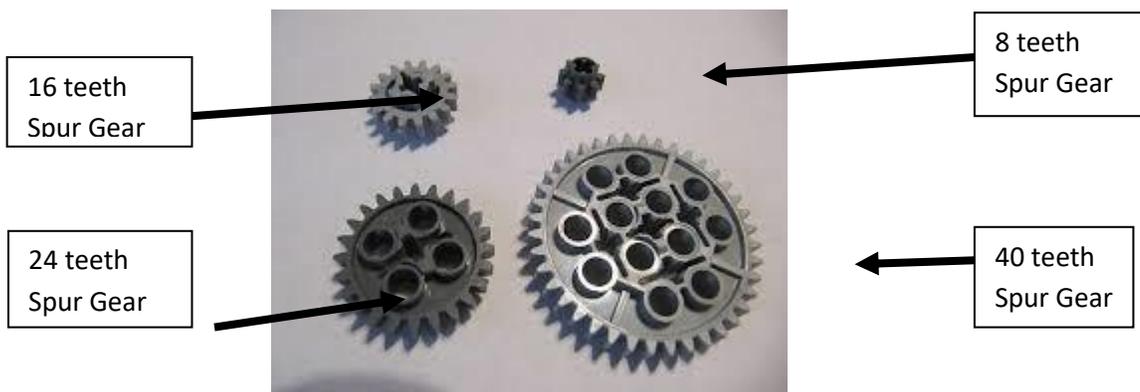Following are the different types of Spur Gears that we have in our Lego NXT.

16 teeth Spur Gear

8 teeth Spur Gear

24 teeth Spur Gear

40 teeth Spur Gear

Fig3.2 (ii) Figure shows different Spur Gears

Few examples of Spur Gears are:
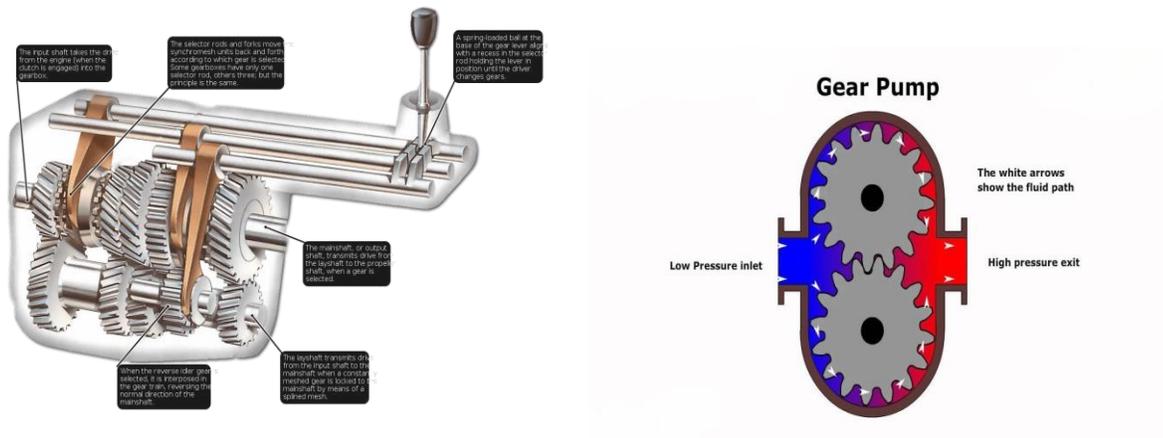
Fig 3.2.iii) shows Gear arrangement of Gear-Box Fig3.2.iv) shows a Gear-Pump

Advantages of Spur Gear:
1. Spur gears have high power transmission efficiency.
2. They are compact and easy to install.
3. They offer constant velocity ratio.
4. Unlike belt drives, spur gear drives have no slip.
5. Spur gears are highly reliable.
6. They can be used to transmit large amount of power (of the order of 50,000 kW).

Disadvantages of Spur Gear:
1. Spur gear drives are costly when compared to belt drives.
2. They have a limited center distance. This is because in a spur gear drive, the gears should be meshed and they should be in direct contact with each other.
3. Spur gears produce a lot of noise when operating at high speeds.
4. They cannot be used for long distance power transmission.
5. Gear teeth experience a large amount of stress.

Applications of Spur Gear:
Spur gears have a wide range of applications. They are used in:

1. Metal cutting machines
2. Power plants
3. Marine engines
4. Mechanical clocks and watches
5. Fuel pumps
6. Washing Machines
7. Gear motors and gear pumps
8. Automobile gear boxes
9. Steel mills
10. Rolling mills

All these application can be achieved using GEAR-TRAINS.
A gear train is a series of gears designed to achieve a particular overall gear ratio.

Below are few ratios of Spur Gear using Gear Trains :
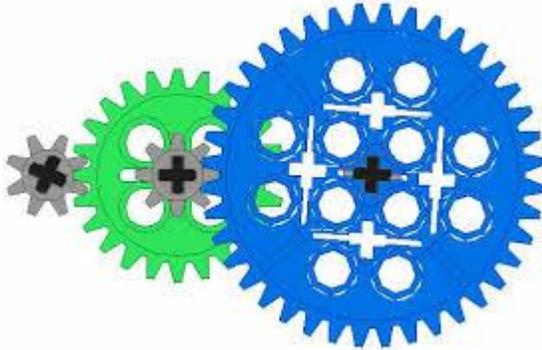
Fig 3.2 (v) Figure shows the Gear Ratio of 1:15(using 1pair of 1:3 and 1 pair of 1:5)
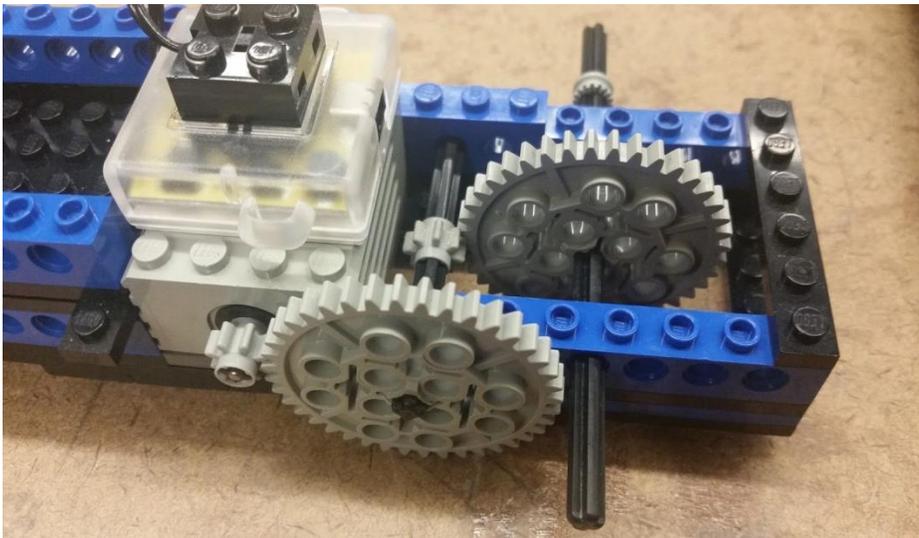
Fig 3.2 (vi) Figure shows the Gear Ratio of 1:25(using 2 pairs of 1:5)
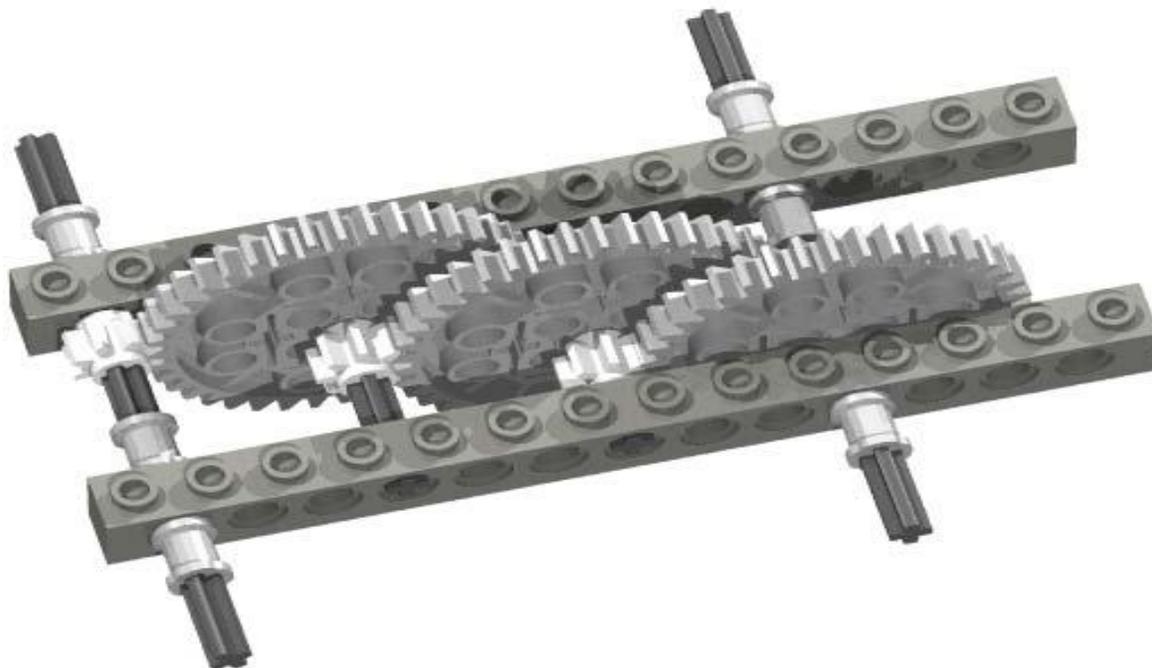
Fig 3.2 (vii) <u>Figure shows the Gear Ratio of 1:125 (using 3 pair of 1:5)</u>

Make a bot using the concept of Gear-Ratio using 1:3 Gear Ratios known as Speedster.

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Q1. *Fill in the blanks:*

1) …………………………………………….has teeth which are parallel to axis of gear.

2) The biggest spur gear has …………………………………………….. tooth.

3) There are ……………………….. gears in the arrangement of 1:125 gear ratio.

Answers: 1) spur gear   2) 40   3) 6

Q2. *Multiple Choice Questions:*

1) How spur gear can be differentiated with other gears?

a) They are used for parallel transmition of power

b) Tooth of spur gear is parallel to the shaft

c) All the above

d) None of the above

2) What are the types of the spur gears present in the NXT kit?

a) 1   c) 3

b) 2   d) 4

3) Which is NOT an example of spur gear?

 a) Automobile gear boxes   c) Rolling mills

b) Steel mills   d) None of these

4) How many rotations will be taken by the 24 tooth gear if it is connected to 8 tooth gear which is being rotated 3 times?

a) 3 times   c) 6 times

b) 1 time   d) 9 times

5) How many rotations will be taken by the 40 tooth gear if it is messed to 8 tooth gear which is being rotated 3 times?

a) 3 times   c) 15 times

c) 5 times   d) 8 times

Answers: 1) c   2) d   3) d   4) a   5) c

Q3. *Answer the following questions:*

1) How many types of spur gear present in NXT kit?

2) Write any two advantages and disadvantages of spur gear.

3) What is gear ratio? How torque can be changed by using gear ratio?

4) Explain the arrangement of following gear train

a) 1:15   b) 1:25   c) 1:9   d)1:75

5) Why gears ration cannot be added or subtracted to each other for making gear train?

6) Which spur gears will be used to make 1:5, 1:3 and 2:3?

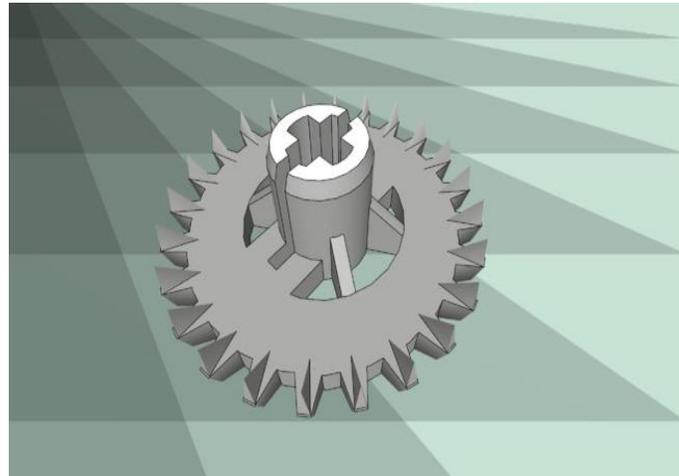7) If 24 tooth gears are rotated 3 times then how many times does the 8 tooth gear be rotated?

CHAPTER-3

KNOB AND CROWN GEAR

(i)   (ii)

Fig 3.3 (i) and (ii) shows the image of Knob Gear and Crown Gear

KNOB GEAR: Gears that have only four teeth over its circumference are called Knob Gears. Knob Gears can only be meshed with another Knob Gear. Knob Gears are much stronger than gear wheels and they can handle significantly higher torque.

Knob wheels can be meshed both in perpendicular and parallel manner. They are most commonly used in the perpendicular set-up, because the regular gears that can transfer such motion are much more likely to break under torque than the knob wheels.

CROWN GEAR: This is a really old design, the first gear among the regular gears which could be meshed in a perpendicular manner. It's weak and inconvenient to use.

The Crown Gear has teeth that are turned on a 90° angle and are used for 90°motion. It works well when meshed with spur and worm but doesn't works well with another Crown Gear.
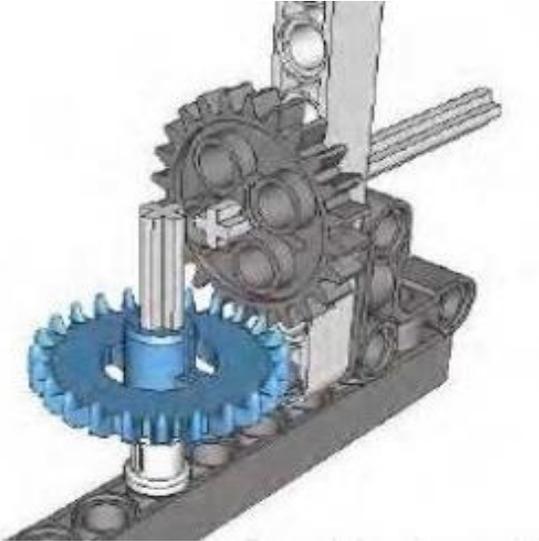
The Crown Gear has 24-teeth.

Fig3.3 iv) A Spur Gear is meshed with Crown Gear for a 90°motion.

Advantages of Knob Gear:

1. Higher load carrying capacity.
2. Smoother and Quieter than spur gear
3. Less wear and tear.
4. Constant output because of the Gear Ratio.

Disadvantages of Knob Gear:

1. These gears can only be used with another Knob Gear.
2. Generation of heat is more.
3. It has more play as compared to any other gear, because of the space between teeth.

TASK ✓

Make a bot that could hit the black and white colored boxes in different directions.

BUILDING:

Below is the image of how to build the bot for this particular task.
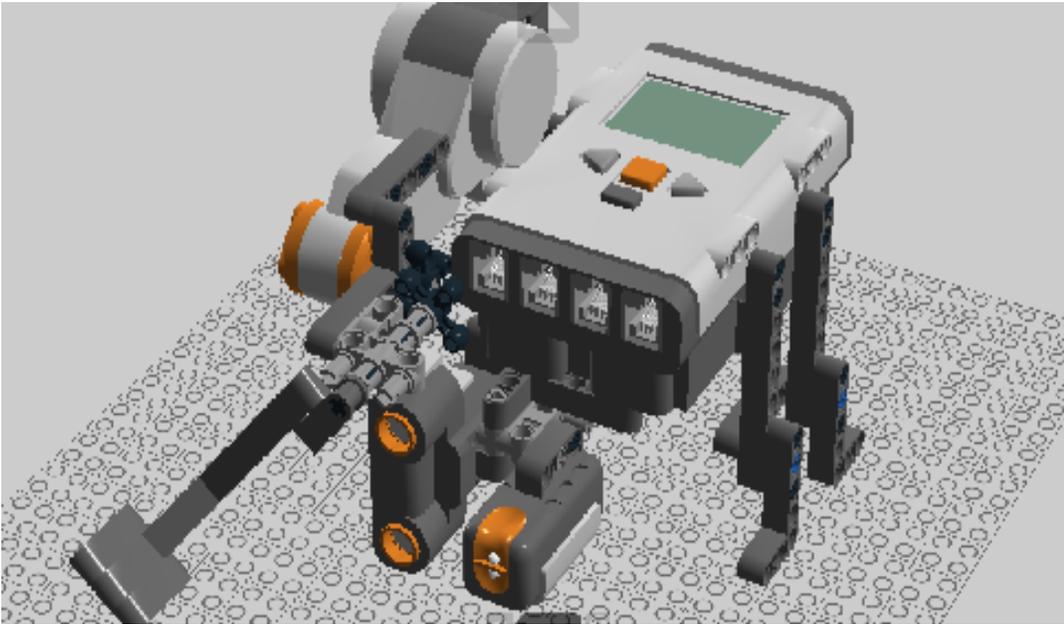
Fig3.3 v) Figure showing the robot structure of Hitting Mechanism
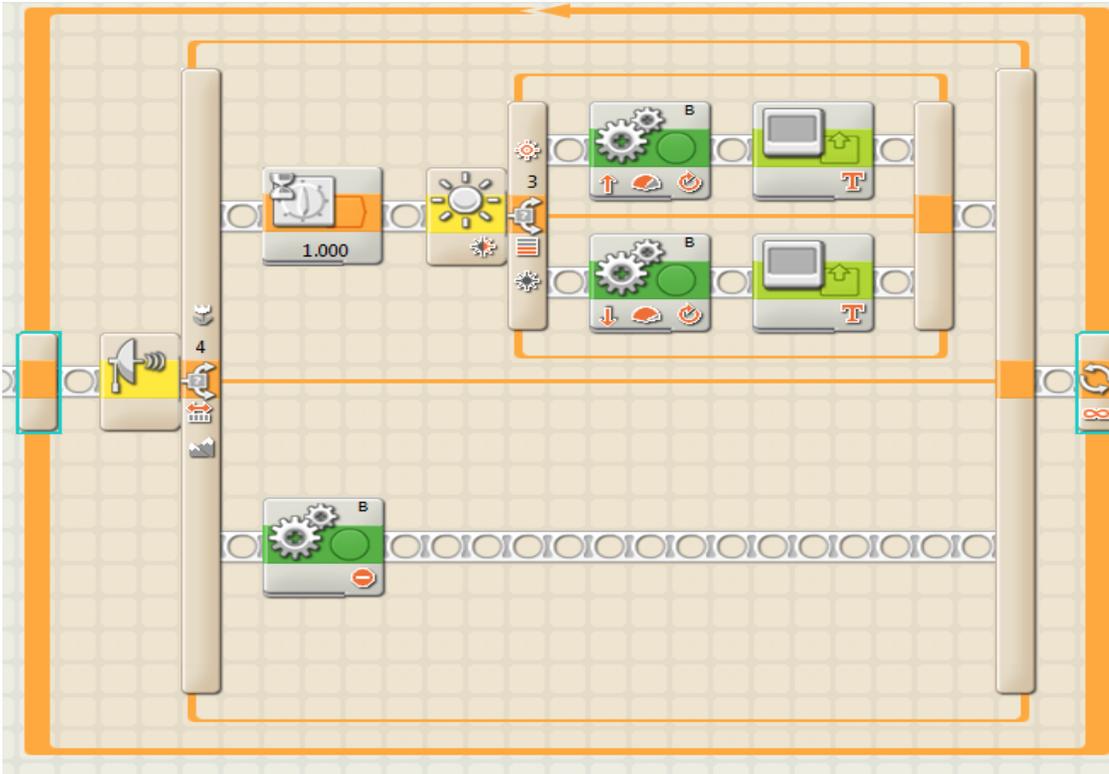
SOLUTION:

Fig3.3. vi) Figure showing programming of Hitting-Bot

Explanation:

1. We will choose one Switch Block with UltraSonic Sensor and configure it to a distance of 7cms.
2. Then we will take another switch block configured to Light Sensor which will differentiate between dark and light color.
3. If the color is any white then motor will move towards right and will display white else it will move towards left and display black.
4. And this whole arrangement is placed in loop so that as soon as UltraSonic Sensor detects obstacle it will do the operation as assigned.
5. Also if Ultrasonic Sensor doesn't detect anything the Motor B will be STOP.

****

Q1. *Fill in the blanks:*

1) The gear which has perpendicular tooth on its circumference is called …………………………………

2) Knob gear has ………………….tooth on its circumference.

3) Crown gear has …………………………..tooth on its circumference.

4) The gears which have angular shaped tooth on its circumference are called ……………………..

Answers: 1) Crown gear   2) 4   3) 24   4) Bevel gear

Q2. *Multiple Choice questions:*

1) Why knob gear is messed only with another knob gear?

a) Because it has 4 tooth gear only

b) Because of its structure.

c) a and b

d) None of these

2) Crown gear cannot be messed with which gear?

a) Spur   b) Bevel   c) Worm   d) Knob

3) What gear ratio will be made if crown gear is messed with 24 tooth gear?

a) 1:1   b) 1:3   c) 1:5   d) None of these

4) Hitting mechanism is application of which gear?

a) Spur Gear   b) Knob Gear   c) Crown Gear   d) None of these

5) Which sensors are used in hitting mechanism?

a) Light sensor   b) Ultrasonic sensor   c) a and b   d) No sensors are used

Answers: 1) b   2) d   3) a   4) b   5) c

Q3. *Answer the following questions:*

1) What do you mean by knob gear and crown gear?

2) What are advantages and disadvantages of knob gear?

3) How blocks are sorted in hitting mechanism?

4) Write the name of programming blocks used for making the program of hitting mechanism.

CHAPTER- 4

WORM AND BEVEL GEAR

BEVEL GEAR

Bevel Gears have conical shaped teeth and the axis of their shafts intersect. They are generally used for a 90°angle but can be used for other angle also.

Bevel Gear has less friction as compared to Crown Gear but they can only be meshed with another Bevel Gear.

| i) | ii) | iii) |

Fig3.4 Figure i), ii), iii) shows the images of different types of double bevel gear i.e. 12-teeth, 20-teeth and 36-teeth.

ADVANTAGES:

➢ High speed and high load

➢ Can even work at different angles.

DISADVANTAGES:

➢ Complicated in design

➢ Requires more precision

WORM GEAR:

This gear can be only used as the driver gear, never as the follower gear. It comes in handy for mechanisms that need to e.g. lift something up and keep it lifted; in this case worm gear acts like a lock that keeps the desired part of mechanism lifted without putting its load on the motor.
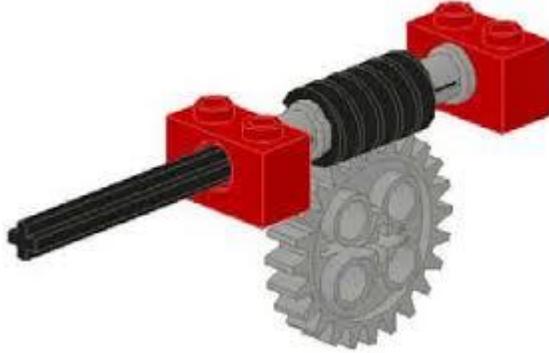
Fig3.4 v) Figure showing Worm Gear meshed with 24-teeth Spur Gear

And the Gear Ratio in the above figure is 24:1.

There is a lot of possible applications for this worm gear's property, for instance many types of cranes or forklifts, railroad barriers, drawbridges, winches, and basically every mechanism that needs to keep something steady once the motor stops.

Secondly, the worm gear is extremely efficient for gearing down. It is theoretically 8 times more efficient that the 8 teeth gear, because every revolution of the worm gear rotates the follower gear by just single teeth. Therefore worm gears are used for gearing down whenever there is a very high torque or low speed needed and there is little space to use.

Finally, as the worm gear rotates, it has a tendency to push against the follower gear and slide along its own axle. Usually this tendency has to be stopped by a strong casing around the worm gear, but there are certain mechanisms that use it to move worm gear from one place to another.

The worm gear can be used with all the listed gears. The most common use is to mesh it with a 24 teeth gear:

ADVANTAGES:
1. The combination of Worm Gear is compact and quiet.
2. It has a Self locking feature as the worm gear is always the driving gear.
3. Meshing is effective as the teeth are parallel to the shaft.
4. It can be used to reduce torque and speed.

DISADVANTAGES:
1. It produces heat at contact point.
2. It has very low efficiency
3. Manufacturing cost is more as worm Gear is .
4. High Power loss.

APPLICATIONS OF WORM GEAR:
1. Gates and Conveyor Belts
2. Elevators/Lifts
3. Tuning Instruments

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Q1. *Fill in the blanks:*

1) …………………………………………..have conical shaped teeth and the axis of their shafts intersect.

2) Worm gear has ……………………………tooth on its circumference.

Answers: 1) Bevel gear   2) 1

Q2. *Multiple choice questions:*

1) Why worm gear is used as a driving gear only?

a) Because it will be very difficult for another gear to move it

b) Because it has only one teeth.

c) Because the gear ratio is large.

d) All above options.

2) How many types of bevel gear are present in the NXT 9797?

a) 1   b) 2   c) 3   d) 4

Answers: 1) a   2) c

Q3. *Answer the following questions:*

1) What are advantages and disadvantages of bevel gear?

2) What are the applications of worm gear?

3) What gear ratio will be made when worm gear is messed with 24 tooh gear which is connected to 40 tooth gear?

4) Write the Gear ratio for the followings:

a) Worm gear is messed with 40 tooth gear.

b) 24tooth gear is messed with 40 tooth gear which is connected to worm gear.

5) What is the difference between spur gear and bevel gear?

6) What is the name of the gear which looks like a spring?