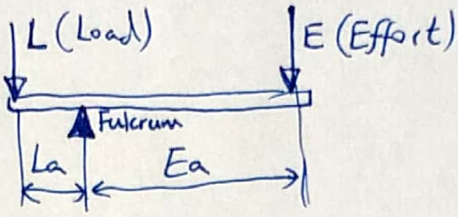
LEVERS

① a) First class.

b)



$L = 2\,kg = 19'6\ N$

$L_a = 15\ mm$

$E_a = 180\ mm$

$E\,?$

Lever's Law:

$E \cdot E_a = L \cdot L_a$

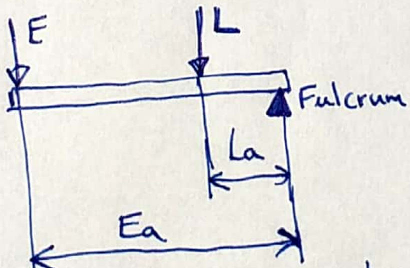
$E \cdot 180\,mm = 19'6\ N \cdot 15\ mm$

$$E = \frac{19'6\ N \cdot 15\ \cancel{mm}}{180\ \cancel{mm}} = 1'63\ N$$

We will need a force of 1'63 N for cutting the wire.

③ a) Second class.

b)



$L = 2 \times 50\ kg = 100\ kg = 981\ N.$

$L_a = 0'4\ m$

$E_a = 1'2 + 0'4 = 1'6\ m$

$E\,?$

Lever's Law:

$E \cdot E_a = L \cdot L_a$

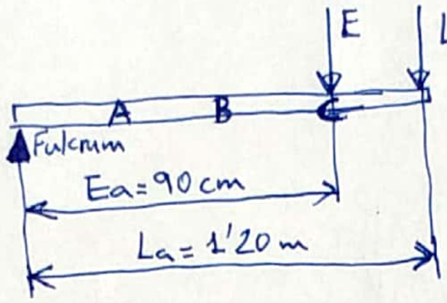
$E \cdot 1'6\,m = 981\ N \cdot 0'4\ m$

$$E = \frac{981\ N \cdot 0'4\ \cancel{m}}{1'6\ \cancel{m}} = 245'25\ N.$$

We need to apply a force of 245'25 N to lift the weight up.

⑤ a) Third class.

b) To lift the load with the minimum effort, we need to hold the shovel in point C, where the effort arm is the greatest.



$L = 20N$

$Ea = 90\ cm$

$La = 120\ cm$

$E?$

Lever's Law:

$E \cdot Ea = L \cdot La$

$E \cdot 90\ cm = 20\ N \cdot 120\ cm$

$E = 26'\hat{6}\ N$

If we hold the shovel in point C, we will need to make an effort of $26'\hat{6}$ N.

PULLEYS

① Using a fixed pulley, $E = L$, so the effort is 50 kg (490'5 N)

To lift the load 2 metres, we have to pull the rope 2 metres too.

② This is a movable pulley, so $E = \frac{L}{2}$, that is: $E = \frac{50\ kg}{2} = 25\ kg$.

So the minimum force to lift the load is 25 kg (245'25 N)

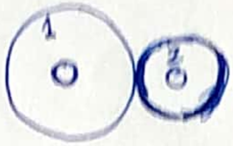
In exchange, we need to pull the rope 6 metres to lift the load 3 metres.

③ This time we use a block and tackle made up of one fixed pulley and one movable pulley. The load hangs from 2 pieces of rope, so the minimum effort is half the load. That is, $E = \frac{L}{2} = \frac{50\ kg}{2} = 25\ kg$.

We have to pull the rope 6 metres to lift the load 3 metres, but this system is better than the one of exercise 2 because we pull the rope down.

FRICTION WHEELS, BELT AND PULLEYS, AND GEARS

(1)



$N_1 = 5000\,rpm$ $D_2 = 5cm$

$D_1 = 10cm$ N_2 ?

$$N_1 \cdot D_1 = N_2 \cdot D_2$$

$$5000\,rpm \cdot 10\,cm = N_2 \cdot 5\,cm$$

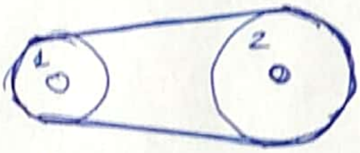
$$\boxed{N_2 = \frac{5000\,rpm \cdot 10\,\cancel{cm}}{5\,\cancel{cm}} = 10{,}000\,rpm}$$

The rotation speed of the driven wheel is 10.000 rpm.

Gear ratio, i:

$$i = \frac{N_2}{N_1} = \frac{10{,}000\,rpm}{5.000\,rpm} = 2$$ The gear ratio is 2.

(4)



N_1 ? $N_2 = 1200\,rpm$

$D_1 = 20\,cm$ $D_2 = 30\,cm$

$$N_1 \cdot D_1 = N_2 \cdot D_2$$

$$N_1 \cdot 20\,cm = 1200\,rpm \cdot 30\,cm$$

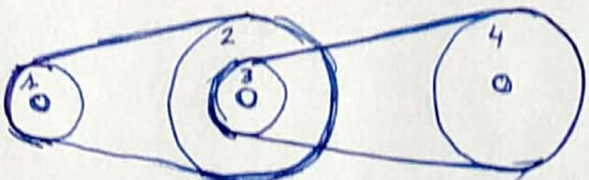
$$\boxed{N_1 = 1800\,rpm}$$

The speed of the driver pulley is 1.800 rpm, so it's a reducing system.

Gear ratio, i:

$$i = \frac{N_2}{N_1} = \frac{1200\,rpm}{1800\,rpm} = 0'\widehat{6}$$ The gear ratio is $0'\widehat{6}$

(7)



$N_1 = 100\,rpm$ $D_2 = 20\,cm$ $D_4 = 30\,cm$

$D_1 = 10\,cm$ $D_3 = 15\,cm$

Scanned with CamScanner

For pulleys 1 and 2: $N_1 \cdot D_1 = N_2 \cdot D_2$

$$100\,rpm \cdot 10\,cm = N_2 \cdot 20\,cm$$

$$\boxed{N_2 = 50\,rpm}$$

Since pulleys 2 and 3 turn in the same axle, $\boxed{N_3 = N_2 = 50\,rpm}$

And for pulleys 3 and 4: $N_3 \cdot D_3 = N_4 \cdot D_4$

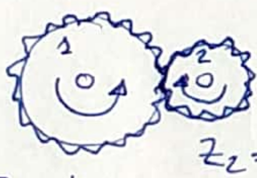
$$50\,rpm \cdot 15\,cm = N_4 \cdot 30\,cm$$

$$\boxed{N_4 = 25\,rpm}$$

Gear ratio of the system:

$$\boxed{i = \frac{N_4}{N_1} = \frac{25\,rpm}{100\,rpm} = 0'25}$$

10



$Z_1 = 40$

$N_1 = 300\,rpm$

$Z_2 = 20$

N_2 ?

$$N_1 \cdot Z_1 = N_2 \cdot Z_2$$

$$300\,rpm \cdot 40 = N_2 \cdot 20$$

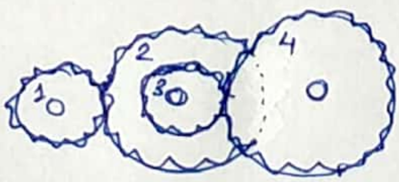
$$\boxed{N_2 = 600\,rpm}$$

The pinion rotates at 600 rpm.

Gear ratio:

$$i = \frac{N_2}{N_1} = \frac{600\,rpm}{300\,rpm} = 2$$

13



$N_1 = 3000\,rpm$ $Z_2 = 30$ $Z_4 = 80$

$Z_1 = 15$ $Z_3 = 20$ N_4 ?

For gears 1 and 2:

$$N_1 \cdot Z_1 = N_2 \cdot Z_2$$

$$3000\,rpm \cdot 15 = N_2 \cdot 30$$

$$\boxed{N_2 = 1500\,rpm = N_3}$$

For gears 3 and 4:

$$N_3 \cdot Z_3 = N_4 \cdot Z_4$$

$$1500\,rpm \cdot 20 = N_4 \cdot 80$$

$$\boxed{N_4 = 375\,rpm}$$

(15) a) Chain and sprockets (mecanismo de ruedas dentadas y cadena).

b) Pulleys and belt (mecanismo de poleas y correa).

c) Every element turns clockwise.

d) $N_1 = 6$ revolutions ; $z_1 = 4$; $z_2 = 16$; N_2 ?

$$N_1 \cdot z_1 = N_2 \cdot z_2$$

$$6 \text{ rev} \cdot 4 = N_2 \cdot 16$$

$$\boxed{N_2 = 1'5 \text{ revolutions}}$$

e) $N_3 = 90$ rpm

$D_3 = 10$ cm

N_4 ?

$D_4 = 2$ cm

$$N_3 \cdot D_3 = N_4 \cdot D_4$$

$$90 \text{ rpm} \cdot 10 \text{ cm} = N_4 \cdot 2 \text{ cm}$$

$$\boxed{N_4 = 450 \text{ rpm}}$$

f) $N_3 = 90 \text{ rpm} = N_2$

$z_2 = 16$

$z_1 = 4$

i ? $\left(= \frac{N_4}{N_1}\right)$

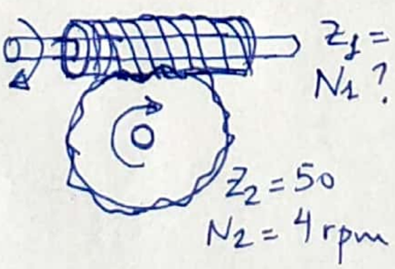
$$N_1 \cdot z_1 = N_2 \cdot z_2$$

$$N_1 \cdot 4 = 90 \text{ rpm} \cdot 16$$

$$\boxed{N_1 = 360 \text{ rpm}}$$

$$\boxed{i = \frac{N_4}{N_1} = \frac{450}{360} = 1'25}$$

(16) Worm gear:



For every revolution of the worm, the wheel turns one tooth.

$$N_1 \cdot z_1 = N_2 \cdot z_2$$

$$N_1 \cdot 1 = 4 \text{ rpm} \cdot 50$$

$$\boxed{N_1 = 200 \text{ rpm}}$$

Gear ratio:

$$\boxed{i = \frac{N_2}{N_1} = \frac{4 \text{ rpm}}{200 \text{ rpm}} = 0'02}$$

(19) Podemos resolver un torno tratándolo como una palanca. Consideramos el brazo de la manivela como el brazo de esfuerzo (effort arm) y el radio del torno como el brazo de carga (load arm). Por tanto,

$$E \cdot E_a = L \cdot L_a$$

$$5\,N \cdot 50\,cm = L \cdot 10\,cm$$

$$\boxed{L = 25\,N}$$

Como máximo podemos levantar una carga de 25 N aplicando una fuerza de 5 N en la manivela.

Si con este torno queremos elevar una carga de 75 kg ($L = 75\,kg = 735'75\,N$), la fuerza necesaria (E) será:

$$E \cdot E_a = L \cdot L_a$$

$$E \cdot 50\,cm = 735'75\,N \cdot 10\,cm$$

$$\boxed{E = 147'15\,N}$$