

Activity 4.1a – All About Simple Machines Answer Key

1. Levers

a)

b) G) LR = 2', LE = 6', E = 1 LB

$$\begin{array}{l} \text{U)} \quad \frac{R}{LE * E = LR * R} \\ \text{E)} \quad LE * E = LR * R \\ \text{S)} \quad 6 * 1 = 2 * R \\ \text{S)} \quad 6 = 2 * R \\ \text{R} = 3 \text{ LB} \end{array}$$

c) G) R = 8 LB, LE = 4', E = 4 LB

$$\begin{array}{l} \text{U)} \quad \frac{LR}{LE * E = LR * R} \\ \text{E)} \quad LE * E = LR * R \\ \text{S)} \quad 4 * 4 = LR * 8 \\ \text{S)} \quad 16 = 8 * LR \\ \text{LR} = 2' \end{array}$$

c) G) R = 13 LB, LR = 2', E = 4 LB

$$\begin{array}{l} \text{U)} \quad \frac{LE}{LE * E = LR * R} \\ \text{E)} \quad LE * E = LR * R \\ \text{S)} \quad LE * 4 = 2 * 13 \\ \text{S)} \quad 4 * LE = 26 \\ \text{LE} = 6.5' \end{array}$$

d) G) R = 50 LB, LR = 3', LE = 5'

$$\begin{array}{l} \text{U)} \quad \frac{E}{LE * E = LR * R} \\ \text{E)} \quad LE * E = LR * R \\ \text{S)} \quad 5 * E = 3 * 50 \\ \text{S)} \quad 5 * E = 150 \\ \text{E} = 30 \text{ LB} \end{array}$$

e) G) R = 113 LB, LR = 2', E = 40 LB

$$\begin{array}{l} \text{U)} \quad \frac{LE}{LE * E = LR * R} \\ \text{E)} \quad LE * E = LR * R \\ \text{S)} \quad LE * 40 = 2 * 113 \\ \text{S)} \quad 40 * LE = 226 \\ \text{LE} = 5.65' \end{array}$$

f) G) LR = 1', LE = 10', E = 1 TON = 2000 LB

$$\begin{array}{l} \text{U)} \quad \frac{R}{LE * E = LR * R} \\ \text{E)} \quad LE * E = LR * R \\ \text{S)} \quad 10 * 2000 = 1 * R \\ \text{S)} \quad 20000 = 1 * R \text{ where } \text{R} = 20000 \text{ LB} \end{array}$$

Load (R)	Resistance Arm (LR)	Effort Arm (LE)	Effort (E)
3 lbs.	2 feet	6 feet	1 lbs.
8 lbs.	2 feet	4 feet	4 lbs.
13 lbs	2 feet	6.5 feet	4 lbs.
50 lbs.	3 feet	5 feet	30 lbs.
113 lbs.	2 feet	5.65 feet	40 lbs.
20,000 lbs = 10 tons	1 foot	10 feet	1 ton

- Answers will vary. Can opener requires less effort to open the can.
- Answers will vary: 1.wheelbarrow 2.tweezers 3.hammer 4.shovel 5.bottle opener
- Yes, because the mechanical advantage increases (leverage increases). The longer the effort arm, the less effort you need to exert.
- 1st Class: Seesaw, scissors, claw hammer removing nail, pliers, nail clipper
 - 2nd Class: wheelbarrow, bottle opener, door, nut cracker, wrench on bolt head
 - 3rd class: shovel, tweezers, tongs, rake, baseball bat

Wheel & Axle

1.
2. G) LE = wheel R = 1' = 12", LR = AXLE R = .5"

U) MA
E) $MA = LE/LR$

S) $MA = 12 / .5$

1.) MA = 24

3. G) E = 80 LB, MA = 24

U) R
E) $E = R / MA$

S) $80 = R / 24$

2.) R = 1920 LB

4. G) D = 2.5'

U) CIRCUMFERENCE
E) $C = \pi * D$

S) $C = 2.5 * \pi$

3.) C = 7.85'

5. **Increase the wheel diameter.**

The Pulley

1.
2. G) R = 1092 LB, E = 80 LB

U) MA
E) $R = MA * E$

S) $1092 = MA * 80$

S) $MA = 1092/80 = 13.65$

1.) 14 Strands Needed

3. G) MA = 7, E = 45 LB

U) R
E) $R = MA * E$

S) $R = 7 * 45$

2.) R = 315 LB

Bonus: MA = 2

The Incline Plane

1.
2. G) L = 12', H = 3' E = 30 LB

U) MA R
E) $MA = L / H$ $R = MA * E$

S) $MA = 12/3$ $R = 4 *$
30

S) MA = 4

R = 120 LB

3. G) L = 9', H = 4.5' R = 123 LB

U) MA E
E) $MA = L / H$ $E = R / MA$

S) $MA = 9/4.5$ $E = 123$
/ 2

S) MA = 2

E = 61.5 LB

Bonus:

E = 30 lb

R = 123 lb

MA = R / E = 123 / 30 = 4.1

MA = C / B = 4.1

C = 4.1 * B

$$\begin{aligned}\sin(\theta) &= B / C \\ \text{SUBSTITUTE FOR C:} \\ \sin(\theta) &= B / (4.1 B) = 1 / 4.1 = .244\end{aligned}$$

$$\begin{aligned}\sin(\theta) &= .244 \\ \theta &= \sin^{-1}(.244) \\ \theta &= 14.1^\circ\end{aligned}$$

The Screw

1. **Answers will vary.** If they have any form of Pitch = 1 / (number of threads per inch) it's correct.
2. **You get more mechanical advantage.**
3. G) 3/8" dia. screw, PITCH = 1/(20 threads per inch) = 0.05 , 1.5" dia screwdriver

U) MA

E) $MA = \pi \cdot D / \text{PITCH}$

S) $MA = \pi \cdot 1.5 / .05$

S) **$MA = 94.2$**