

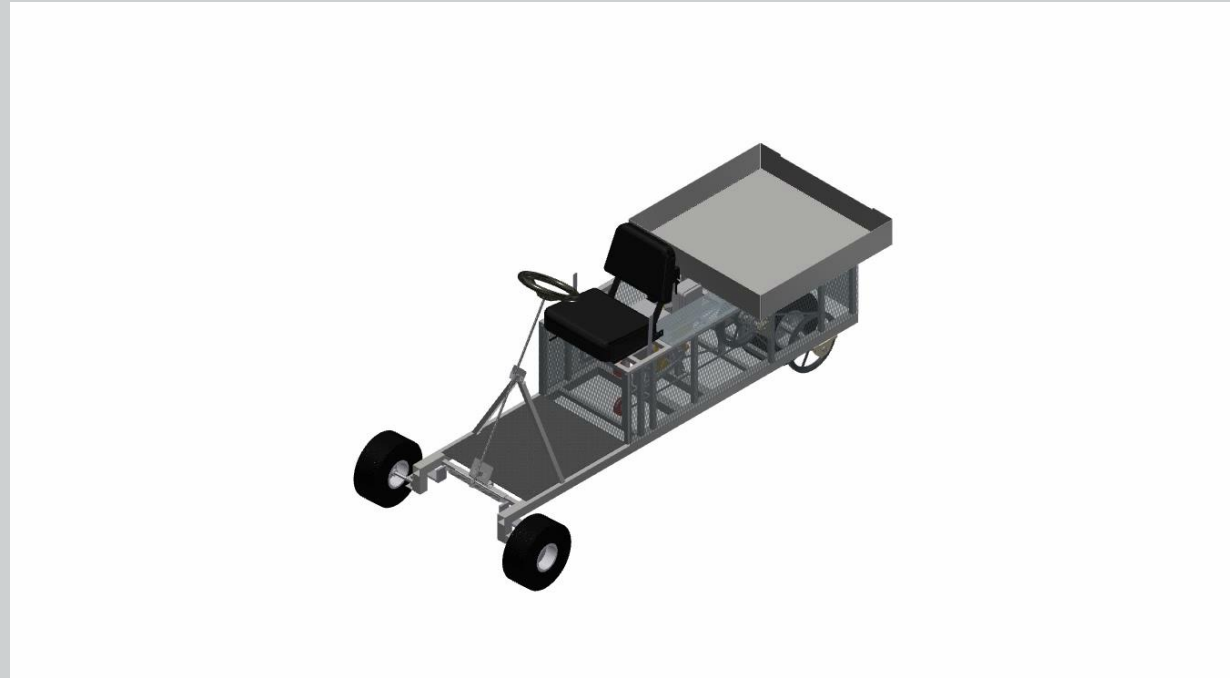


Group 12

Machine Design Final Project

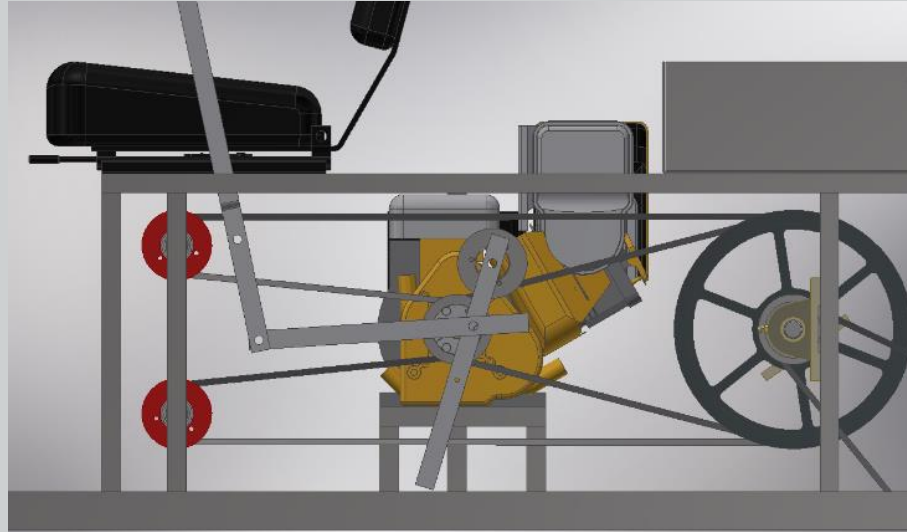
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General Layout

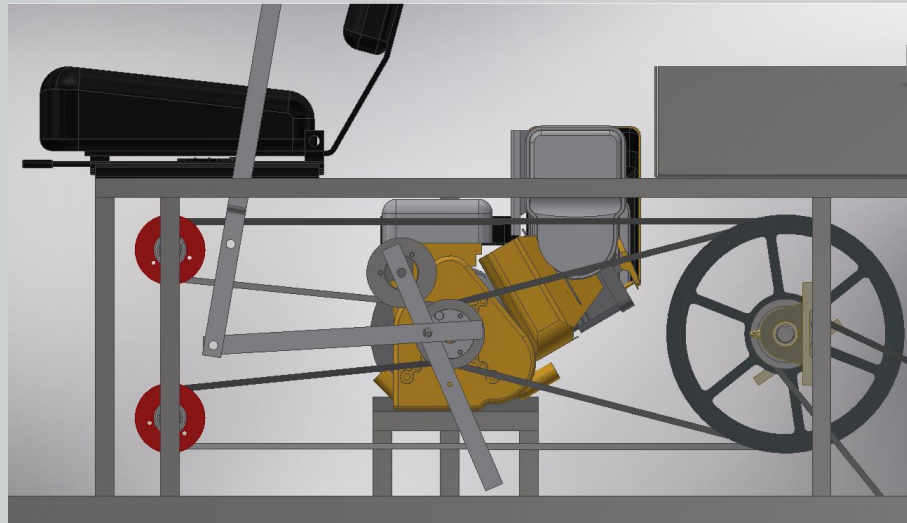


- Wheel layout
 - Two front for steering and one powered rear
- Engine selection
 - Power calculation
 - 10 hp Briggs & Stratton 1150 Horizontal OHV Engine
- Transmission selection
 - Belt pulley clutch system
- Overall Dimensions
 - Length: 8' 10"
 - Height: 4' 3"
 - Width: 3' 9"
 - Weight: approximately 550lb

Transmission System



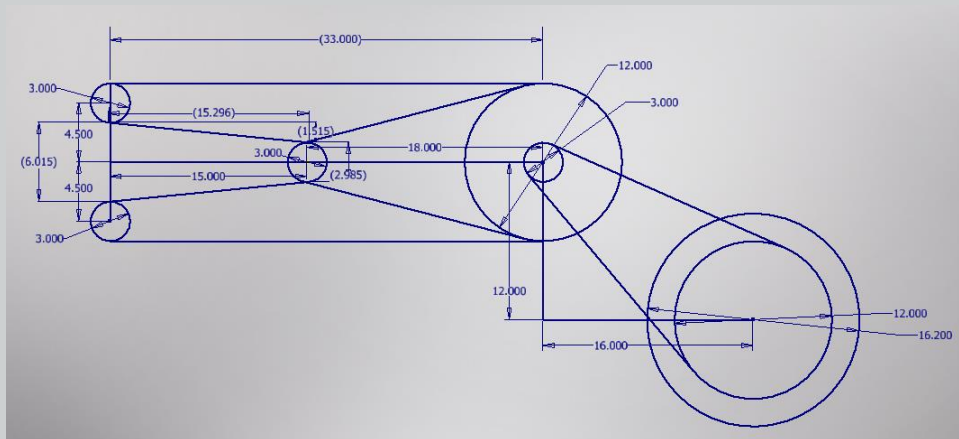
Forward Operation



Reverse Operation

- Forward/Reverse operation based on alternating belt tension with linkage
- Utilizes double V-belts to accommodate reverse motion
- Two 4:1 belt reductions
 - Reverse: 3" double pulley, (2) 3" single pulleys, 12" double pulley, 12" single pulley
 - Forward: 3" double pulley, 12" double pulley, 12" single pulley

Belt Lengths



- Used Inventor to aid in obtaining geometry for calculations
- Critical dimensions: $C, D, d, \theta_d, \theta_D$
- Double V-belt lengths chosen
 - Forward from engine: Gates AA62 (62" – 1.34" oversized)
 - Reverse from engine: VBG AA136 (136" – 6.86" oversized)
 - Reduction to drive: Gates A65 (65" – 0.42" oversized)

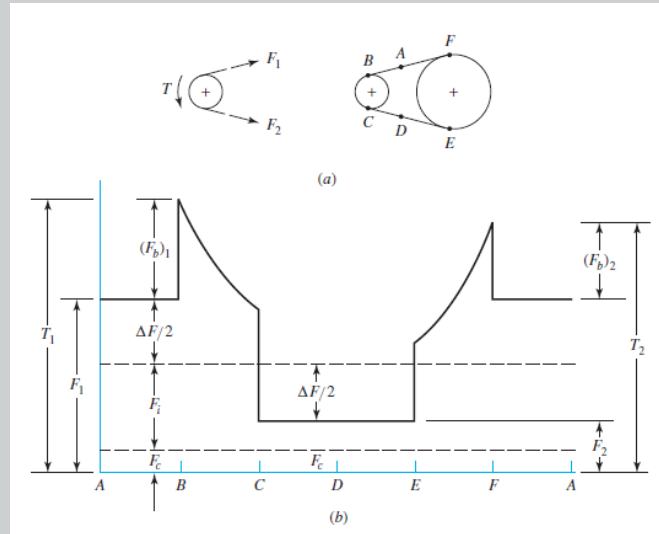
$$L_p = 2C + \pi(D + d)/2 + (D - d)^2/(4C) \quad (17-16a)$$

V-belt length equation

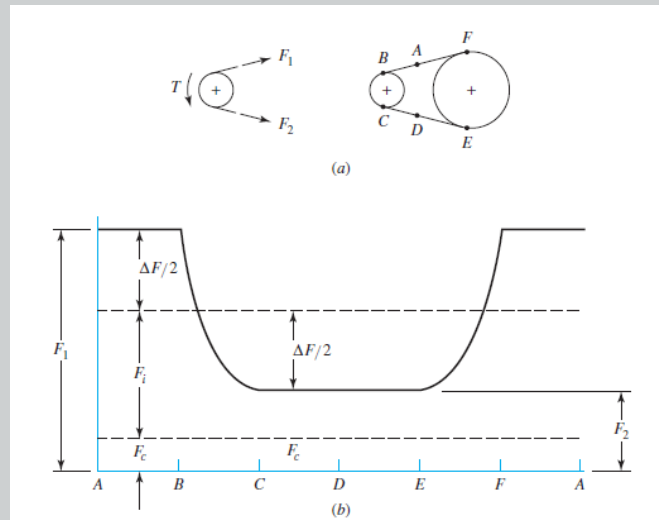
$$L = [4C^2 - (D - d)^2]^{1/2} + \frac{1}{2}(D\theta_D + d\theta_d) \quad (17-2)$$

Flat belt length equation

Belt Tensions



V-Belt Tension Variation



Flat Belt Tension Variation

- Made assumption to model double V belts as flat belts for ease of calculation
- Note that tension varies throughout each belt (assumption of similarity used to simplify calculations)
- Largest tension: 522.43 lbf (3" single pulley reduction)
- Smallest tension: 30.95 lbf (3" double pulley engine)
- Creative idea to estimate reverse transmission tensions

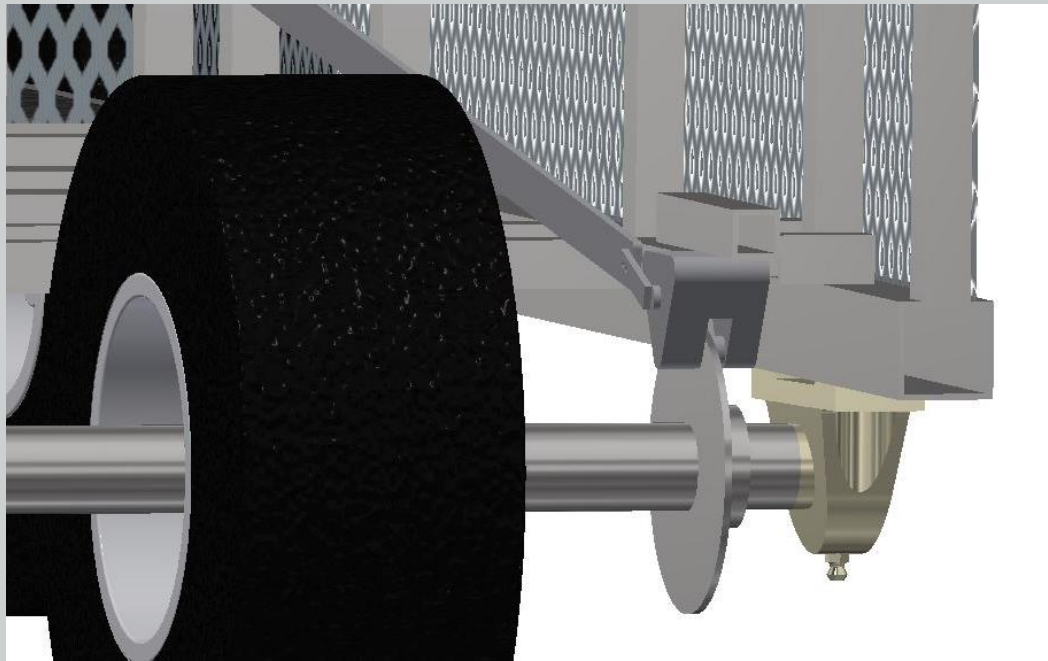
Reduction Shaft Design



- Major components
 - Bearings
 - Spacers
 - 3" Single Pulley
 - 12" Double Pulley
 - Keys

Shaft Designation: AISI 1050 CD Speed = 950 rpm
1"-1.25"-1.5"-1.25"-1"
Lowest $n_f = 1.63$ Lowest $n_y = 3.63$

Braking System



- Disk brake with mechanically activated caliper
- Estimated friction force from kinematic equations
 - $V_f^2 = V_i^2 + 2a(x_f - x_o)$ and $\Sigma F = ma$
 - V_i from drive shaft rpm and wheels
 - Reasonable braking distance set (10ft – 0.44g)
 - F_{fr} estimated as 525.64 lbf

Drive Shaft Design



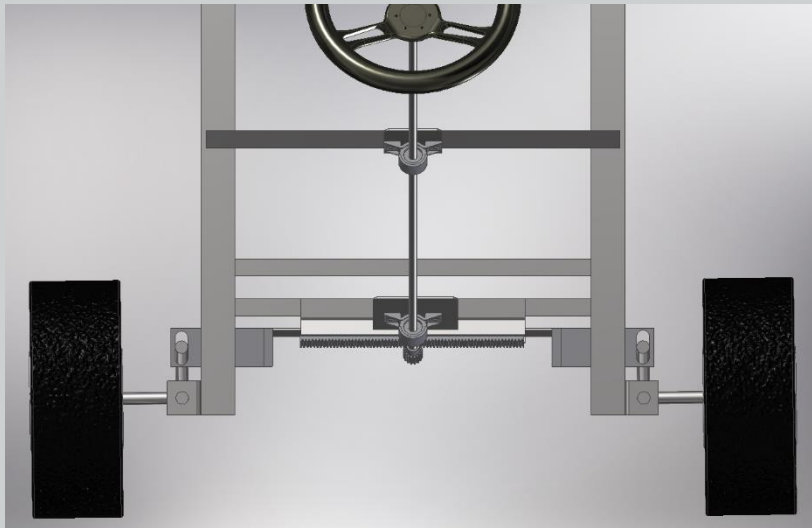
- Major components
 - Bearings
 - Spacers
 - Brake Disk
 - 12" Single Pulley
 - Hubs
 - Keys

Shaft Designation: AISI 1020 CD Speed = 237.5 rpm
1.25"-1.5"-1.8"-1.5"-1.25"
Lowest $n_f = 1.63$ Lowest $n_y = 4.56$

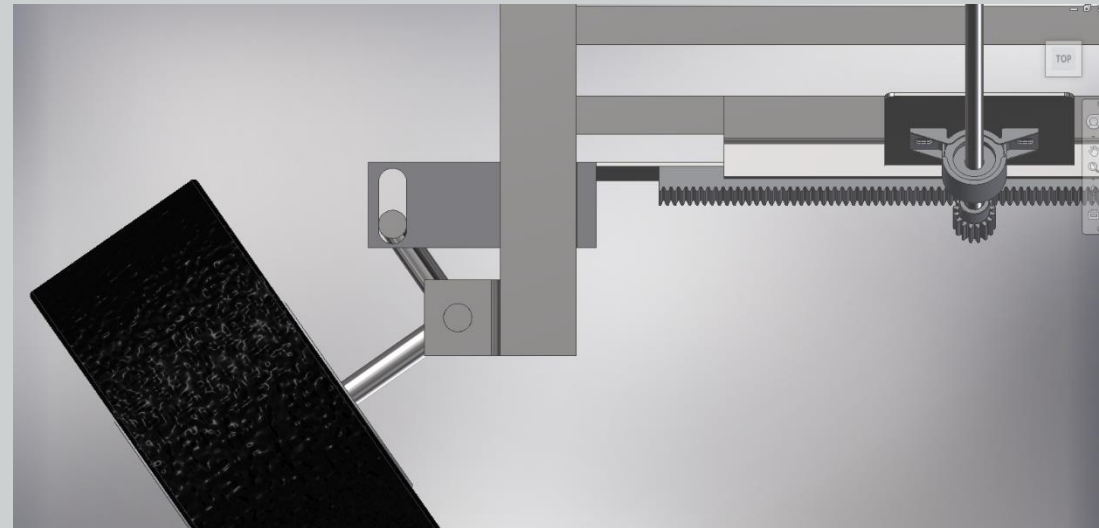
Steering System



- Gear selection
 - High-Load Metal Gear – 20 Degree Pressure Angle
- General layout
 - Rack and pinion steering
 - Lock to lock: 1.2 rotations of steering wheel
 - Maximum turning angle: 38 degrees
 - Turning radius: 9' 2"



Overall Steering Configuration



Max Turning Angle

Design Considerations

- Belts accessible for ease of replacement
- All wearable parts are bolted to frame for ease of replacement
- Belt guards to protect user from belt slippage/breaking
- Belt guards out of expanded metal to allow heat dissipation and airflow to engine
- Upgraded muffler to reduce noise output of engine
- Upgraded seat to include seat belt and seat adjustment for comfort/safety
- Large loading bed for range of work applications
- User friendly transmission control with intuitive setting (can not engage reverse and forward simultaneously)

Cost Projection

Master Purchased Parts List

Part Number	Name	Supplier	Unit Price	Quantity to Purchase	Total Cost
15T212-0160-F8	10hp Gas Engine	Northern Tool + Equipment	\$269.99	1	\$269.99
6209K198	12" Double Pulley	McMaster Carr	\$95.38	1	\$95.38
6209K236	12" Single Pulley	McMaster Carr	\$86.77	1	\$86.77
6209K111	3" Double Pulley	McMaster Carr	\$27.13	2	\$54.26
6209K201	3" Single Pulley	McMaster Carr	\$18.56	3	\$55.68
KDBRKIT3PC	Brakes	Gopowersports.com	\$59.00	1	\$59.00

Labor Calculation Cost

Type of Labor	Cost/Hr of Labor	Expected Hours of Labor	Total Cost of Labor
Shipping and Receiving	\$20.00	1	\$20.00
Initial Inspection	\$20.00	1.5	\$30.00
Standard Machining	\$20.00	18	\$360.00
General Assembly	\$20.00	40	\$800.00
Welding	\$40.00	3	\$120.00
Welding (via PRI Robotics)	\$1.87 per weld	(2)	(\$84.15)
Final Inspection	\$20.00	2	\$40.00
Shipping	\$20.00	2	\$40.00
TOTAL	--	67.5	\$1,410.00

T12211	2" x 2" tubing	Metals Depot	\$79.44	1	\$79.44
F1181	1" x 1/8" flat bar	Metals Depot	\$9.20	1	\$9.20
S112	12 ga sheet metal	Metals Depot	\$88.00	1	\$88.00
5913K61	Steering Bearing	McMaster Carr	\$10.95	2	\$21.90
5174T2	Steering Rack	McMaster Carr	\$23.46	1	\$23.46
5172T21	Steering Gear	McMaster Carr	\$22.00	1	\$22.00
410219	13" Steering Wheel	BMI Karts & Supplies	\$14.95	1	\$14.95
P218	2' x 4' Diamond plate	Metals Depot	\$66.48	1	\$66.48
E11418F	4' x 8' Expanded Metal	Metals Depot	\$144.00	1	\$144.00

- Material Cost
 - \$1,986.50
- Labor Cost
 - \$1,410.00
- Total Cost
 - \$3,396.50
- Sell Price
 - \$5,099.99
 - 50% profit margin

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Questions