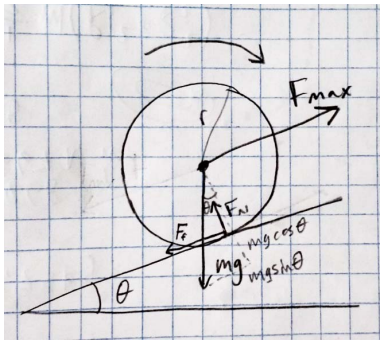
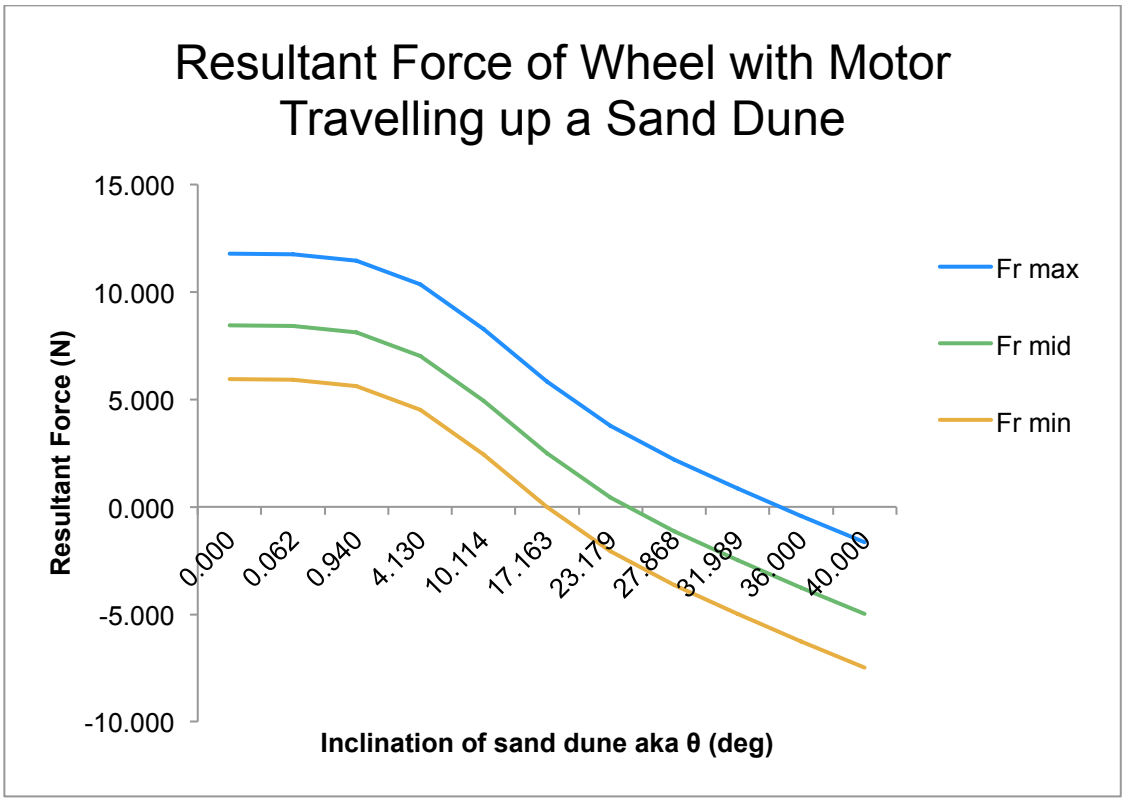
Motor Force V1.1 – Sept. 26, 2016



name	parameter	unit	value	expression
rated motor torque	T	N m	0.4002	specs from datasheet
scale factor motor torque	k	/	0.6	closer to reality
inner radius of wheel	r1	m	0.0475	
outer radius of wheel	r2	m	0.0550	
radius of wheel	r	m	0.0550	
mass robot total	mtotal	kg	2	
mass wheel	m	kg	0.500	
angle of incline	θ	deg	10	
angle of incline radians	θrad	rad	0.175	
sand static friction	us	/	0.850	uninformed estimate
sand kinetic friction	uk	/	0.700	uninformed estimate
max speed on grass	vgrass	m/s	0.130	from gps measurements
time to reach max speed	taccel	s	3	observation
acceleration on grass	agrass	m/s^2	0.0433	
gravity	g	m/s^2	9.81	
force of motor	Fm	N	0.1374	Fm = r/T
moment of inertia for wheel	I	kg m^2	0.00132	I = (1/2)m(r1^2 + r2^2)
acceleration from torque	a	m/s^2	16.671	a = (T*r)/I
force maximum	Fmax	N	11.717	Fmax = ma + (mg*cosθ*uk)
force to overcome	Fo	N	3.407	Fo = mtotal*g*sinθ
force resultant	Fr	N	8.310	Fmax-Fo
will wheel slip?	1 = yes, 0 = no	/	0	if Fr < 1, then yes it will slip
sense of scale	s	kg	1.19	Fmax/g



	robot motor force (N)		
	Fmax	Fo	Fr
1	**3.661**	**0.342**	**3.319**
2	**27.419**	**12.611**	**14.808**
3	10.367	1.710	8.657
4	10.200	5.078	5.122
5	8.628	9.810	-1.182
avg	12.055	5.910	6.145

calculations

Fnet = ma
Fmax - Ff = ma
Fmax = ma + (mg*cosθ*uk)

ΣT = Tnet
T = I * α α = (a/r)
T = I * (a/r)
a = (T*r)/I

scenario 1: global min

name	parameter	unit	value
rated motor torque	T	N m	0.1334
scale factor motor torque	k	/	0.2
inner radius of wheel	r1	m	0.0475
outer radius of wheel	r2	m	0.0550
radius of wheel	r	m	0.0550
mass robot total	mtotal	kg	2
mass wheel	m	kg	0.300
angle of incline	θ	deg	1
angle of incline radians	θrad	rad	0.017
sand static friction	us	/	0.850
sand kinetic friction	uk	/	0.300
max speed on grass	vgrass	m/s	0.130
time to reach max speed	taccel	s	3
acceleration on grass	agrass	m/s^2	0.0433
gravity	g	m/s^2	9.81
force of motor	Fm	N	0.4123
moment of inertia for wheel	I	kg m^2	0.00079
acceleration from torque	a	m/s^2	9.262
force maximum	Fmax	N	3.661
force to overcome	Fo	N	0.342
force resultant	Fr	N	3.319
will wheel slip?	1 = yes, 0 = no	/	0
sense of scale	s	kg	0.37

scenario 2: global max

name	parameter	unit	value
rated motor torque	T	N m	0.667
scale factor motor torque	k	/	1
inner radius of wheel	r1	m	0.0475
outer radius of wheel	r2	m	0.0550
radius of wheel	r	m	0.0550
mass robot total	mtotal	kg	2
mass wheel	m	kg	2.000
angle of incline	θ	deg	40
angle of incline radians	θrad	rad	0.698
sand static friction	us	/	0.850
sand kinetic friction	uk	/	0.900
max speed on grass	vgrass	m/s	0.130
time to reach max speed	taccel	s	3

acceleration on grass	agrass	m/s^2	0.0433
gravity	g	m/s^2	9.81
force of motor	Fm	N	0.0825
moment of inertia for wheel	I	kg m^2	0.00528
acceleration from torque	a	m/s^2	6.946
force maximum	Fmax	N	27.419
force to overcome	Fo	N	12.611
force resultant	Fr	N	14.808
will wheel slip?	1 = yes, 0 = no	/	0
sense of scale	s	kg	2.80

scenario 3: rolling along the beach

name	parameter	unit	value
rated motor torque	T	N m	0.3335
scale factor motor torque	k	/	0.5
inner radius of wheel	r1	m	0.0475
outer radius of wheel	r2	m	0.0550
radius of wheel	r	m	0.0550
mass robot total	mtotal	kg	2
mass wheel	m	kg	0.500
angle of incline	θ	deg	5
angle of incline radians	θrad	rad	0.087
sand static friction	us	/	0.850
sand kinetic friction	uk	/	0.700
max speed on grass	vgrass	m/s	0.130
time to reach max speed	taccel	s	3
acceleration on grass	agrass	m/s^2	0.0433
gravity	g	m/s^2	9.81
force of motor	Fm	N	0.1649
moment of inertia for wheel	I	kg m^2	0.00132
acceleration from torque	a	m/s^2	13.893
force maximum	Fmax	N	10.367
force to overcome	Fo	N	1.710
force resultant	Fr	N	8.657
will wheel slip?	1 = yes, 0 = no	/	0
sense of scale	s	kg	1.06

scenario 4: carrying a payload in front up a small hill

name	parameter	unit	value
rated motor torque	T	N m	0.2668
scale factor motor torque	k	/	0.4

inner radius of wheel	r1	m	0.0475
outer radius of wheel	r2	m	0.0550
radius of wheel	r	m	0.0550
mass robot total	mtotal	kg	2
mass wheel	m	kg	0.700
angle of incline	θ	deg	15
angle of incline radians	θrad	rad	0.262
sand static friction	us	/	0.850
sand kinetic friction	uk	/	0.700
max speed on grass	vgrass	m/s	0.130
time to reach max speed	taccel	s	3
acceleration on grass	agrass	m/s^2	0.0433
gravity	g	m/s^2	9.81
force of motor	Fm	N	0.2061
moment of inertia for wheel	I	kg m^2	0.00185
acceleration from torque	a	m/s^2	7.939
force maximum	Fmax	N	10.200
force to overcome	Fo	N	5.078
force resultant	Fr	N	5.122
will wheel slip?	1 = yes, 0 = no	/	0
sense of scale	s	kg	1.04

scenario 5: traversing up a mini sand dune with a payload in front

name	parameter	unit	value
rated motor torque	T	N m	0.2001
scale factor motor torque	k	/	0.3
inner radius of wheel	r1	m	0.0475
outer radius of wheel	r2	m	0.0550
radius of wheel	r	m	0.0550
mass robot total	mtotal	kg	2
mass wheel	m	kg	0.750
angle of incline	θ	deg	30
angle of incline radians	θrad	rad	0.524
sand static friction	us	/	0.850
sand kinetic friction	uk	/	0.700
max speed on grass	vgrass	m/s	0.130
time to reach max speed	taccel	s	3
acceleration on grass	agrass	m/s^2	0.0433
gravity	g	m/s^2	9.81
force of motor	Fm	N	0.2749
moment of inertia for wheel	I	kg m^2	0.00198
acceleration from torque	a	m/s^2	5.557

force maximum	Fmax	N	8.628
force to overcome	Fo	N	9.810
force resultant	Fr	N	-1.182
will wheel slip?	1 = yes, 0 = no	/	1
sense of scale	s	kg	0.88