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Rover Vehicle Measuring Robot for Great Physical Experiments

PW | JINR | DUBNA 2018

main goals:

GPE Collider robot is an versatile measurement rover.
Rover will acquire complex data for physical experiments such as: magnetic field, radiation, and data from close environment.

Rover, controlled with easily understandable interface should let user to wirelessly ride on various surfaces closed to horizontal.

main goals:

- mechanics:
  - designing
  - durability
  - assembling
  - easy attachment various measuring intruments
  - adatpive suspension
  - suitable wheels

main goals:

- measurments:
  - magnetic field
  - radiation
  - thermal imaging
  - data from close environment i.e.: humidity, air pressure, lighting.
  - distance

main goals:

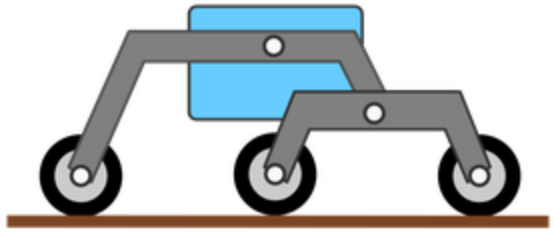
- programming and control:
  - rover's control system standing on myRIO by National Instruments
  - propulsion
  - power supply module
  - wireless control
  - autonomous control by real time imaging camera
  - HMI

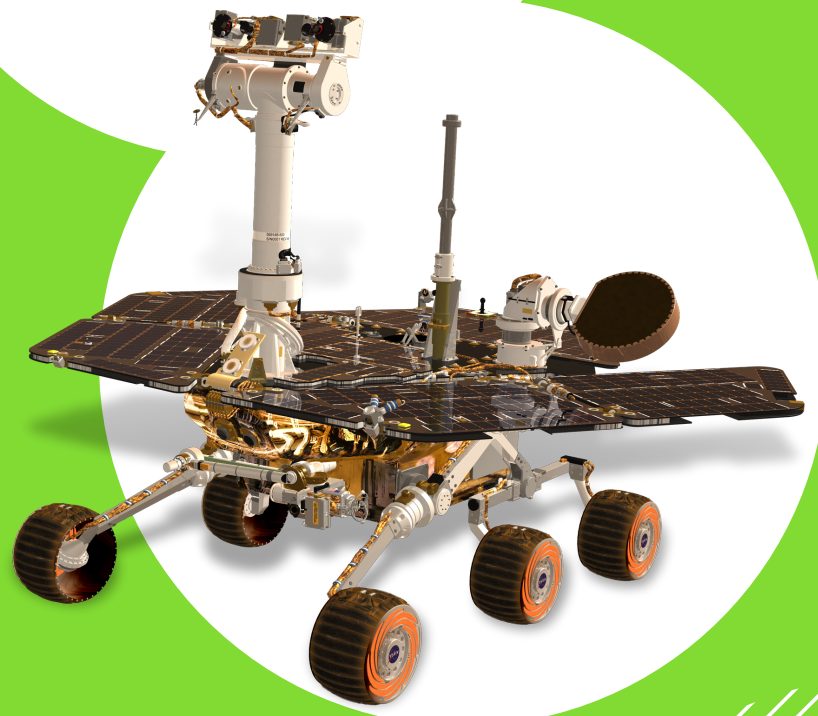
until now
achivements

mechanics

SUSPENSION

Due to assumption of rover's ability to move in various, even difficult surfaces closed to horizontal there will be used suspension of Rocker-Bogie type. Solution, commonly used in many rover's projects (i.e.: NASA Curiosity) allows to easilly move rover in flat and corrugated surfaces.



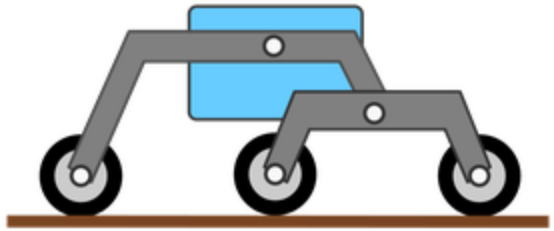


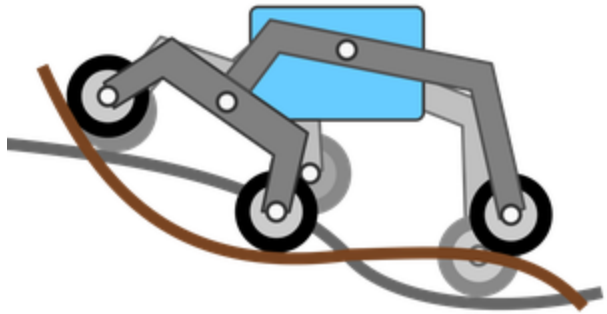
mechanics

SUSPENSION

Body of Colldier is attatched to only one axle - it is very signifant to watch it's center of gravity to maintain it in one position. The most heavy components should be placed possibly on the very bottom.

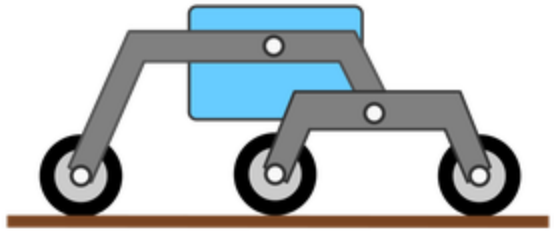
Constatnt position of body also provides constatnt position of measuring instruments.



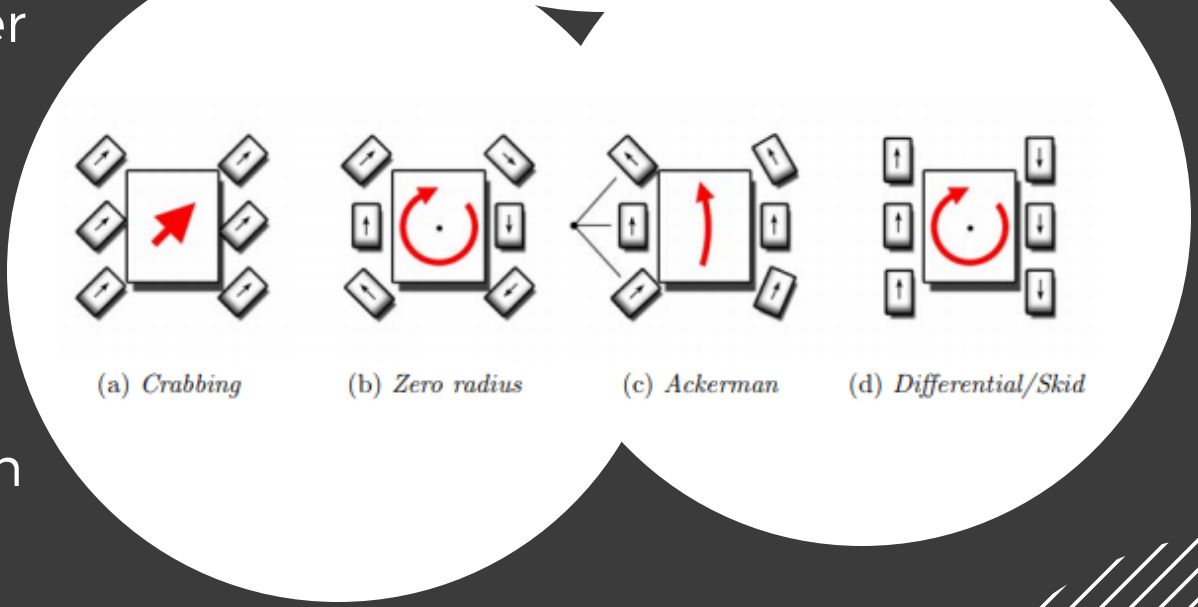


mechanics

SUSPENSION



Rocker-Bogie suspension demands using six motors.
Moreover, by sufficient power of used motors rover vehicle is even able to overcome stairs.

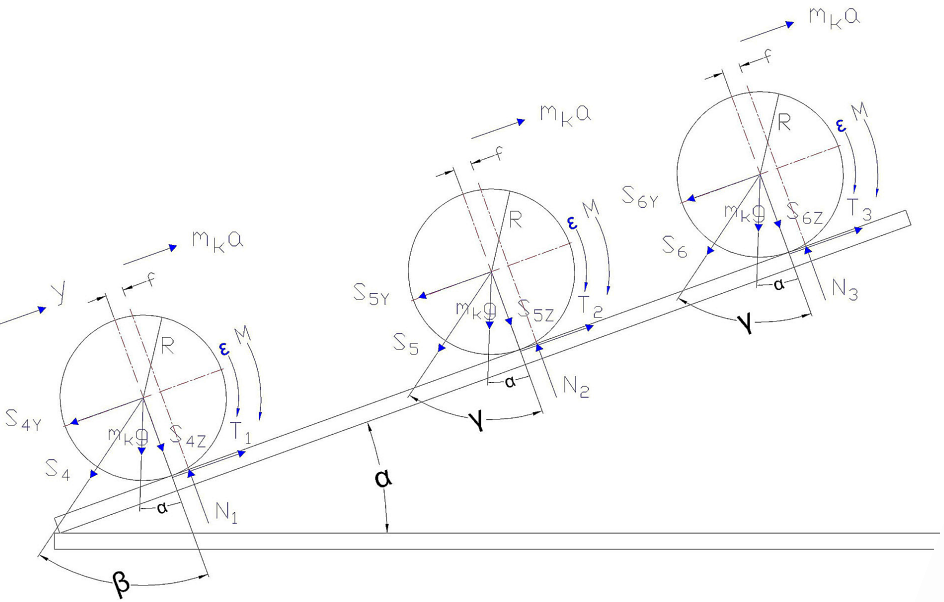


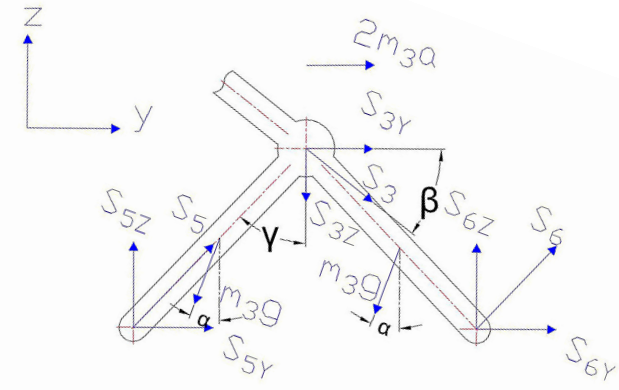
Turning of the rover will be provided by contrary rotation of motors each side (d).

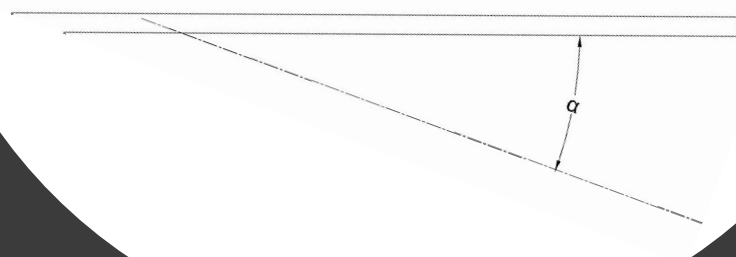
mechanics

MOTOR

To find appropriate motors which would be able to disperse rover to some velocity it is needed to do some math first...







mechanics

MOTOR

$$M = M\left(v, A, m_i, R, J_k, \rho_p, S_D, C_D, \alpha\right)$$

$$M = \frac{\frac{S_D C_D \rho_p}{2(6m_k + 2m_1 + 2m_2 + 4m_4 + m_b)} v^2 \left[A\left(m_k R + \frac{J_k}{R}\right) + (2m_1 + 2m_2 + 4m_4 + m_b)\right] + gsin\alpha[Am_k(R + fctg\alpha) + (2m_1 + 2m_2 + 4m_4 + m_b)]}{A} [Nm]$$

$$A(\beta, \gamma) = 2\left(\frac{tg\beta}{f + Rtg\beta} + \frac{tg\gamma}{f + Rtg\gamma}\right)\left[\frac{1}{m}\right]$$

There was formulated needed motor's generated moment to reach above-cited velocity, dependently on wanted acceleration and physical parameters of the rover.
Model accepted for calulation was simplified.

mechanics

MOTOR

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$$M = \frac{\frac{S_D C_D \rho_p}{2(6m_k + 2m_1 + 2m_2 + 4m_4 + m_b)} v^2 \left[A\left(m_k R + \frac{J_k}{R}\right) + (2m_1 + 2m_2 + 4m_4 + m_b)\right] + g sin\alpha [A m_k (R + f ctg\alpha) + (2m_1 + 2m_2 + 4m_4 + m_b)]}{A} [Nm]$$

$$A(\beta, \gamma) = 2\left(\frac{tg\beta}{f + Rtg\beta} + \frac{tg\gamma}{f + Rtg\gamma}\right)\left[\frac{1}{m}\right]$$

Main parameters are given:

- total mass of the body - 4kg
- total mass of the instruments - 4kg
- J_K - wheel's moment of inertia (stated with Autodesk Invetor program)
- v - maximum velocity (3m/s)
- γ,β - parameters related with geometry of suspension
- α - slope angle
- S_D ,C_D - geometrical parameters related with air resitance
- f - coefficient of friction durng rotation

mechanics

MOTOR

$$M = M\left(v, A, m_i, R, J_k, \rho_p, S_D, C_D, \alpha\right)$$

$$M = \frac{\frac{S_D C_D \rho_p}{2(6m_k + 2m_1 + 2m_2 + 4m_4 + m_b)} v^2 \left[A\left(m_k R + \frac{J_k}{R}\right) + (2m_1 + 2m_2 + 4m_4 + m_b)\right] + gsin\alpha[Am_k(R + fctg\alpha) + (2m_1 + 2m_2 + 4m_4 + m_b)]}{A} [Nm]$$

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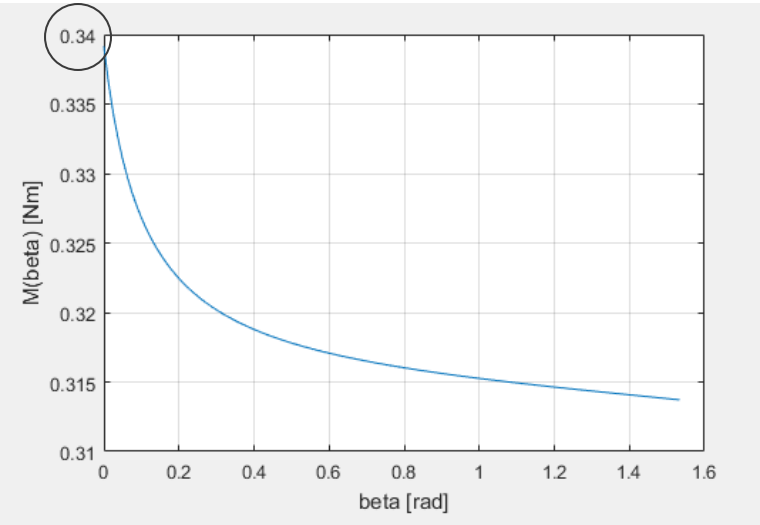
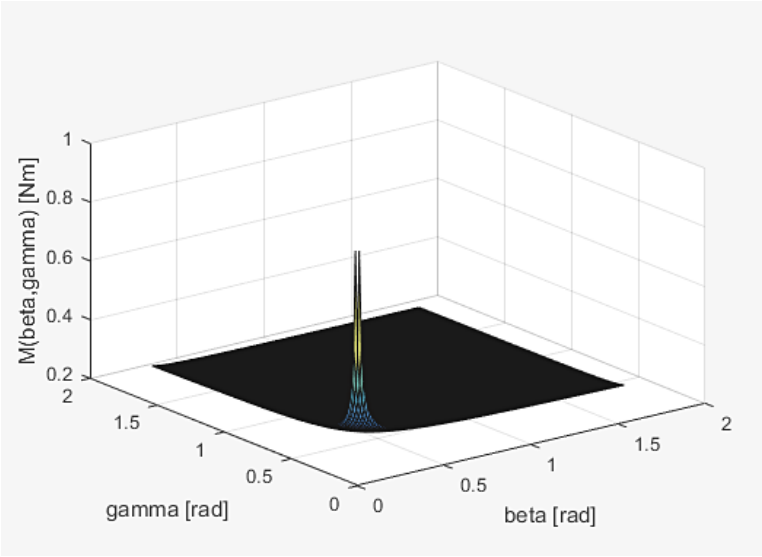




mechanics

MOTOR

Metal Gearmotor specifications:

- diameter / lenght - 25 mm / 52 mm
- nominal speed - 110 rpm
- nominal torque - 423 mNm
- stall current - 1100 mA
- voltage - 12V DC
- reduction ratio - 46.85 : 1
- motor type - 1.1A stall 12V (LP 12V)

Magnetic encoders used.

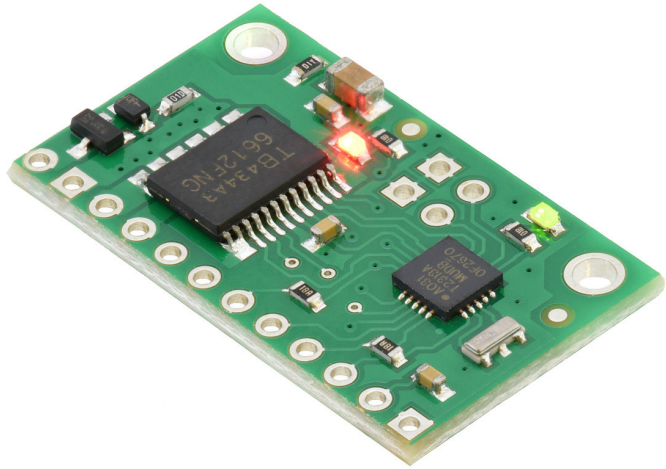
Metal Gearmotor 25Dx52L mm LP
12V by Polou
Engine with planetary gear motor

programming and control:

MOTOR CONTROLLER

Drivers provided by producer's electronic circuit (H-bridge).

- motor channels - 2
- minimum operating voltage: 4.5 V
- maximum operating voltage: 13.5 V
- maximum PWM frequency - 32 kHz
- LP motor control



Pololu Qik 2s9v1 Dual Serial Motor Controller

mechanics

WHEELS

To design and define exact parameters of powering wheel such as moment of interia, mass Inventor program was used.
Each element will be fabricated using 3D printer.
Material of wheel: Z-ULTRAX (stiff and shock durable)
Material of tire: Z-PETG (flexible)

mechanics

WHEELS

For checking the durability of designed wheel with used materials, there was created dynamic symulation of total load of 50N on the wheel's axle.
Maximum deformation obtained was approx. 3μm.

watch

THANK YOU