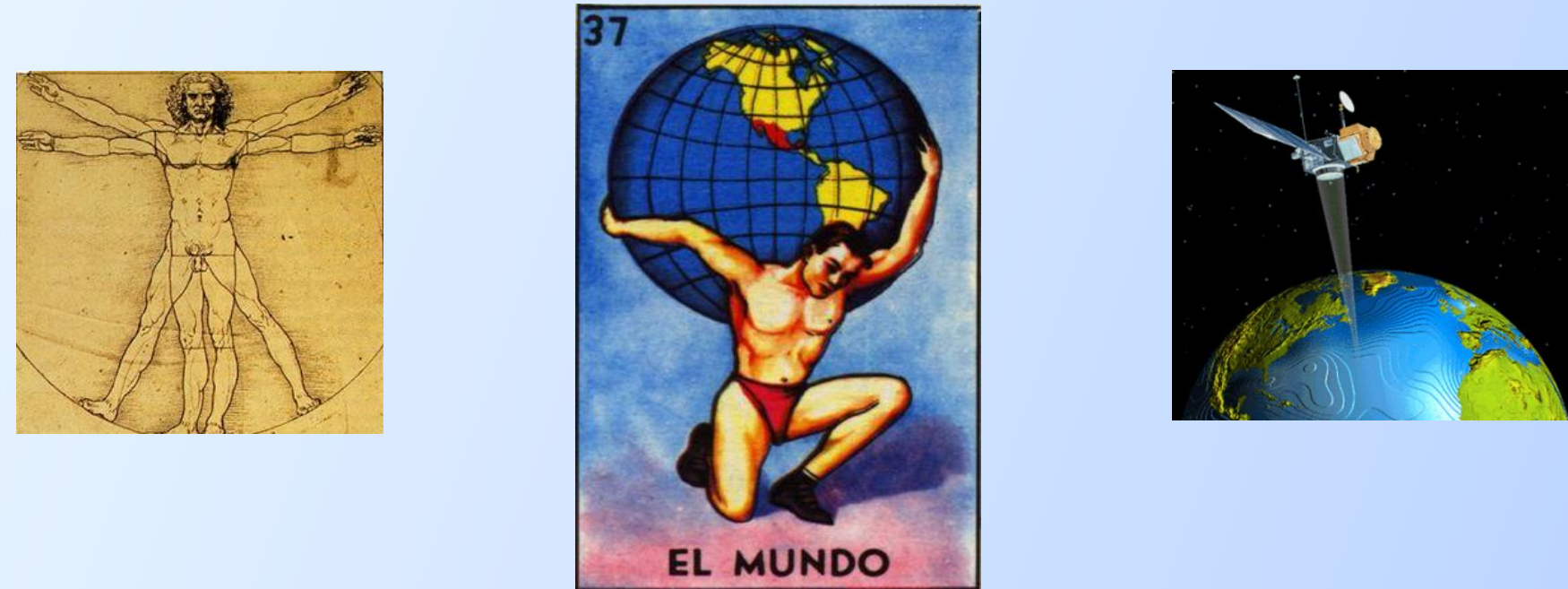# On the Basics of Motion

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### San Diego City College NSF Grant # DUE0653277

Introduction

Gait analysis or the study of human motion has been a subject of intense study since the time of the ancient Greeks; Aristotle(384-322 B.C.) and his contemporaries studied animal motion at both the physical and metaphysical planes. Many ancient cultures also looked to the sky and imagined what was happening with those "lights" that moved across the heavens. On their daily travels the planets, Mars, the god of war, Jupiter, the King of the gods, gave rise to mystical and scientific advances in mythology and science. This project focuses on modeling human and planetary motion to construct basic structures used in both satellite and robotic science.

Methods
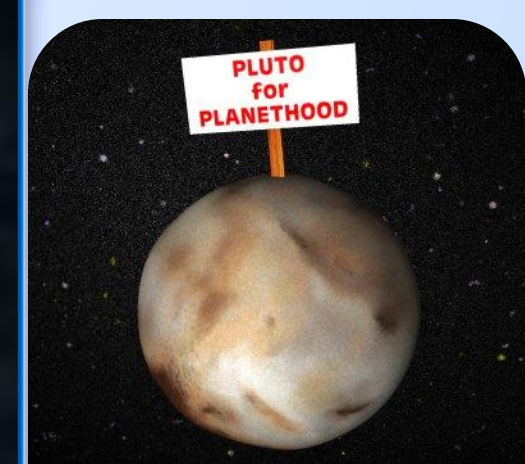
Science journals, refereed papers, and library science techniques were used to gather basic information for this poster. We gathered the basic laws that govern both systems of motion.

Kepler's Laws of Planetary Motion

1. "The orbit of every planet is an ellipse with the sun at a focus."
2. "A line joining a planet and the sun sweeps out equal areas during equal intervals of time."
3. "The square of the orbital period of a planet is directly proportional to the cube of the semi-major axis of its orbit."
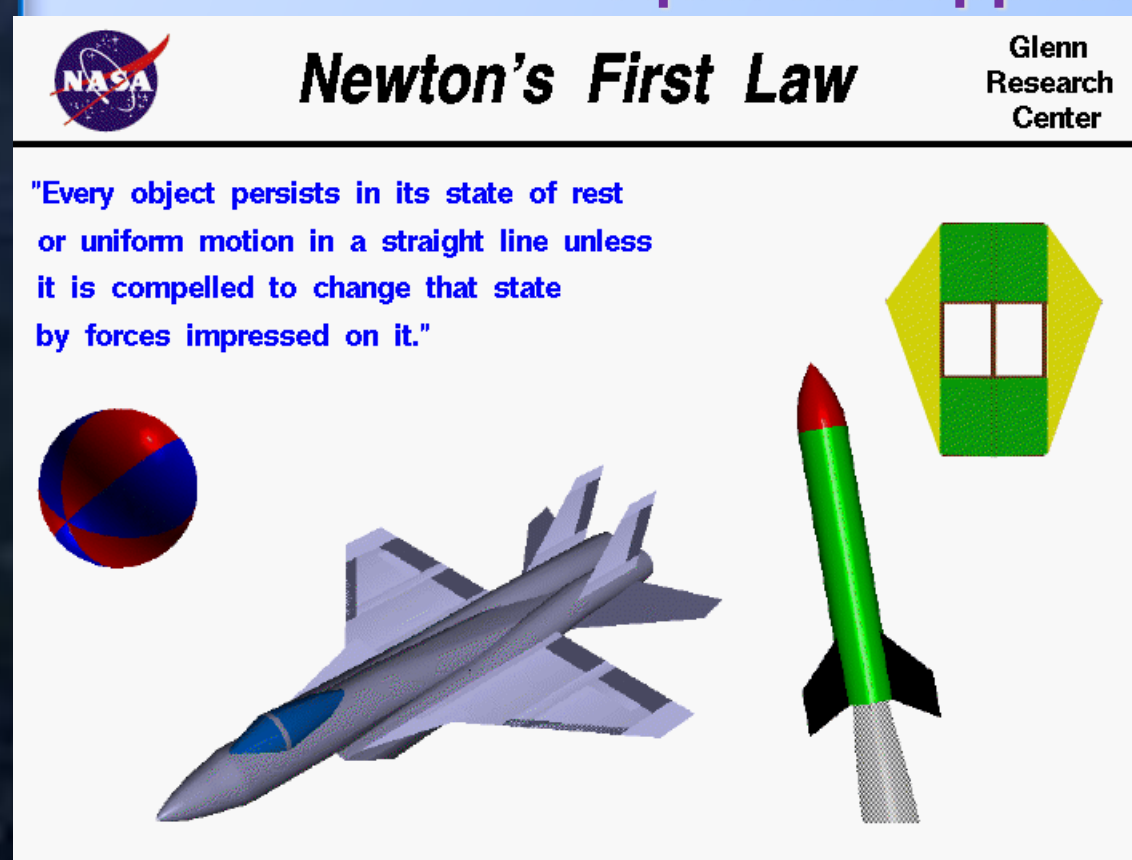
$$T^2 = ka^3$$
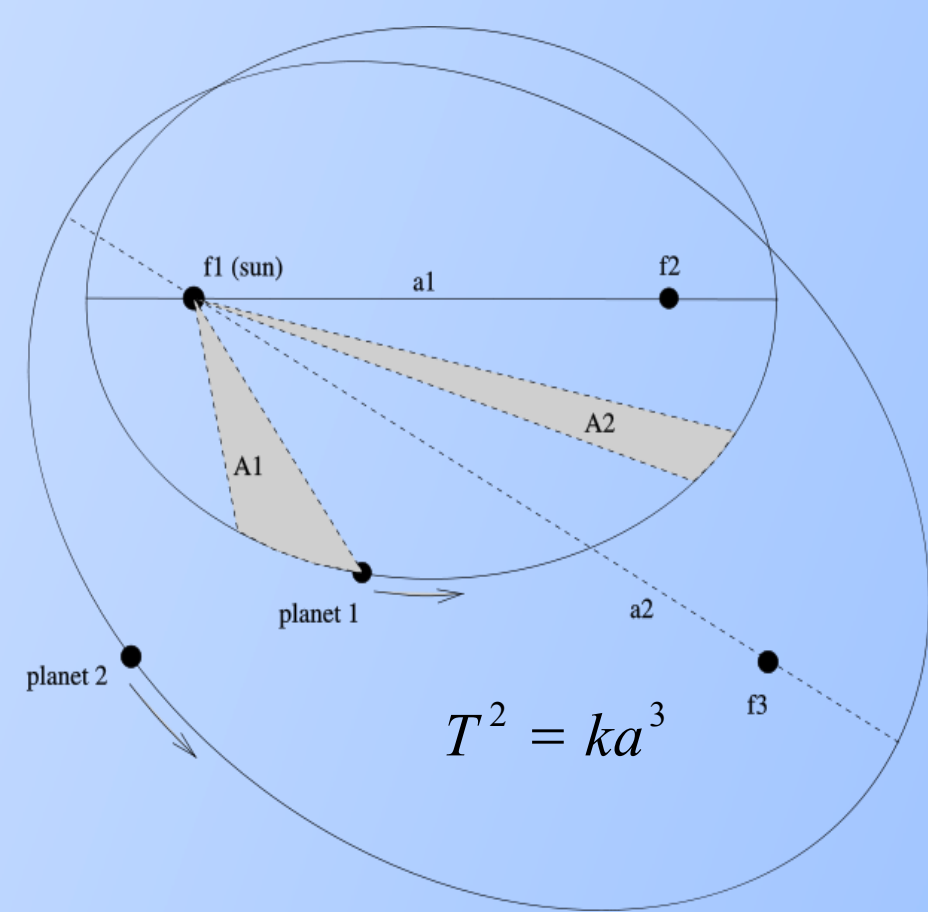
Newton's Laws of Motion

1st Law – A body at rest remains at rest unless acted upon by an external force.
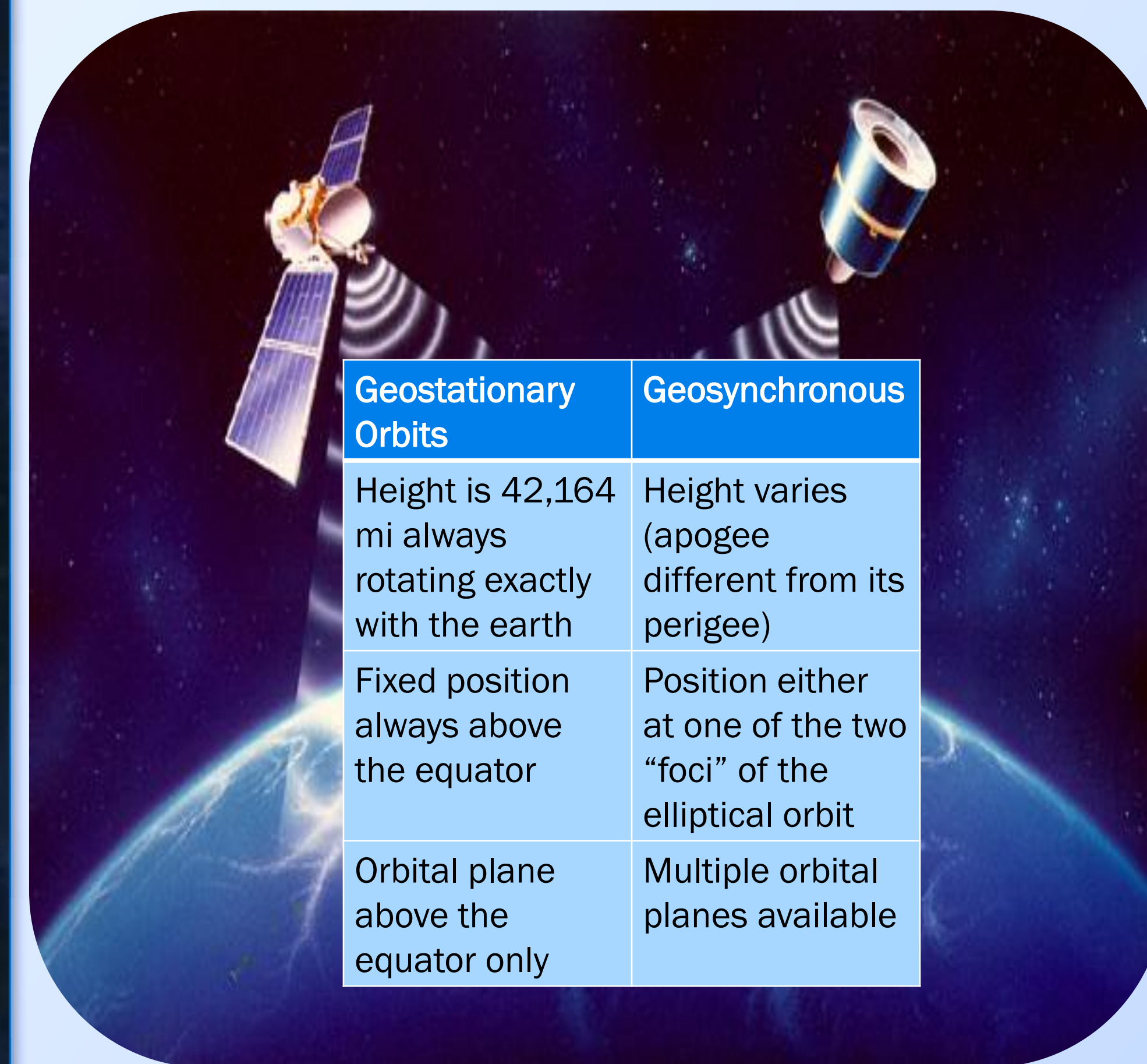
$$I = \int_a^b y^2 \rho \omega(y) dy$$

2nd Law – F=ma

3rd Law – For every action there is an equal and opposite reaction.

Results

Satellite Motion Comparison Chart

Geostationary Orbits	Geosynchronous
Height is 42,164 mi always rotating exactly with the earth	Height varies (apogee different from its perigee)
Fixed position always above the equator	Position either at one of the two "foci" of the elliptical orbit
Orbital plane above the equator only	Multiple orbital planes available

Model of Human Arm Movement

Equation of Arm Motion

$$\tau = \mathbf{M}(\mathbf{q})\mathbf{q}'' + \mathbf{V}(\mathbf{q}, \mathbf{q}') + \sum \mathbf{J}_i^T m_i \mathbf{g} + \sum \mathbf{J}_k^T \begin{bmatrix} -\mathbf{F}_k \\ -\mathbf{M}_k \end{bmatrix} + \mathbf{K}(\mathbf{q} - \mathbf{q}^N)$$

Subject to joint, actuator torque, and path constraint limits.
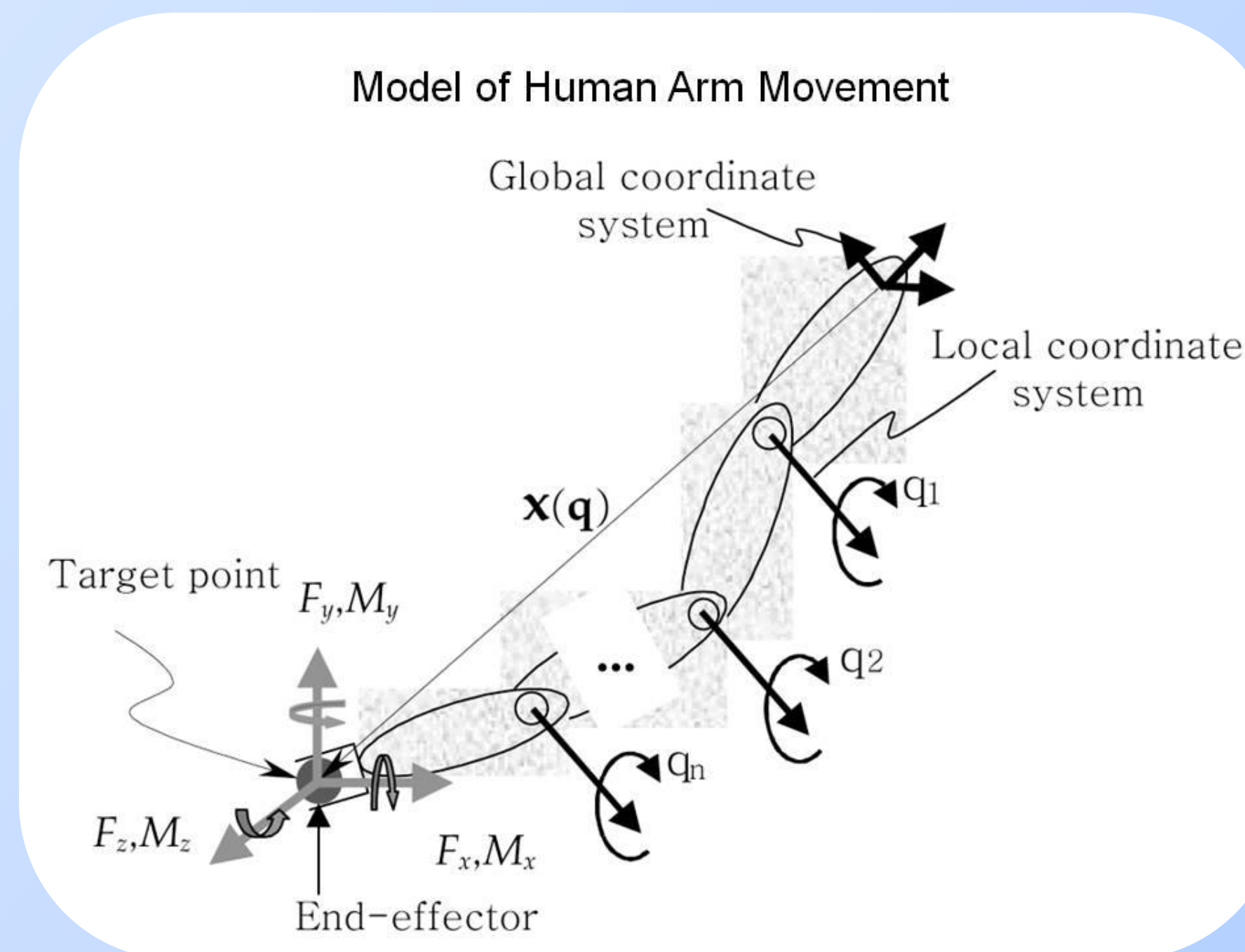
Consider a satellite with mass M_{sat} orbiting a central body with a mass of mass $M_{Central}$. If the satellite moves in circular motion, then the net centripetal force acting upon this orbiting satellite is given by the relationship.

$$F_{net} = (M_{sat} \cdot v^2) / R$$

However, when considering a decaying orbit one must consider the motion of the two bodies where µ is the change in mass.

$$\mu r'' = -\frac{k}{r^2} + \frac{l^2}{\mu r^3}$$

http://www.glenbrook.k12.il.us/gbssci/phys/Class/circles/u6l4c.html

In this *I, Robot* still, we see a robot next to the character Del Spooner, played by Will Smith, who has had his left arm replaced with a bionic one after a car accident. During the film Del confronts the issue of making life decisions with AI methods.

In Quantum Mechanics algorithms are being developed to allow robots to have an artificial social consciousness.
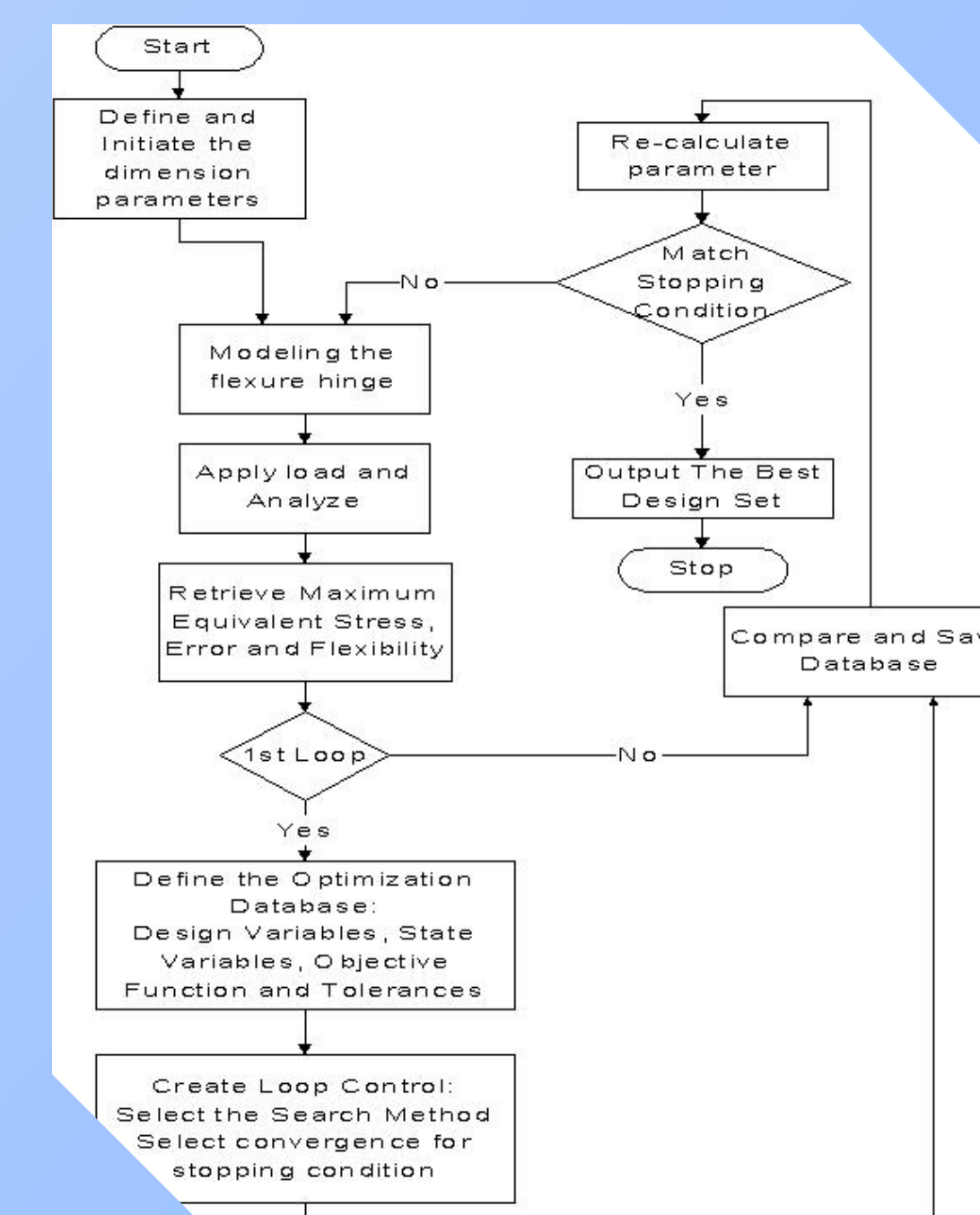
Future Research
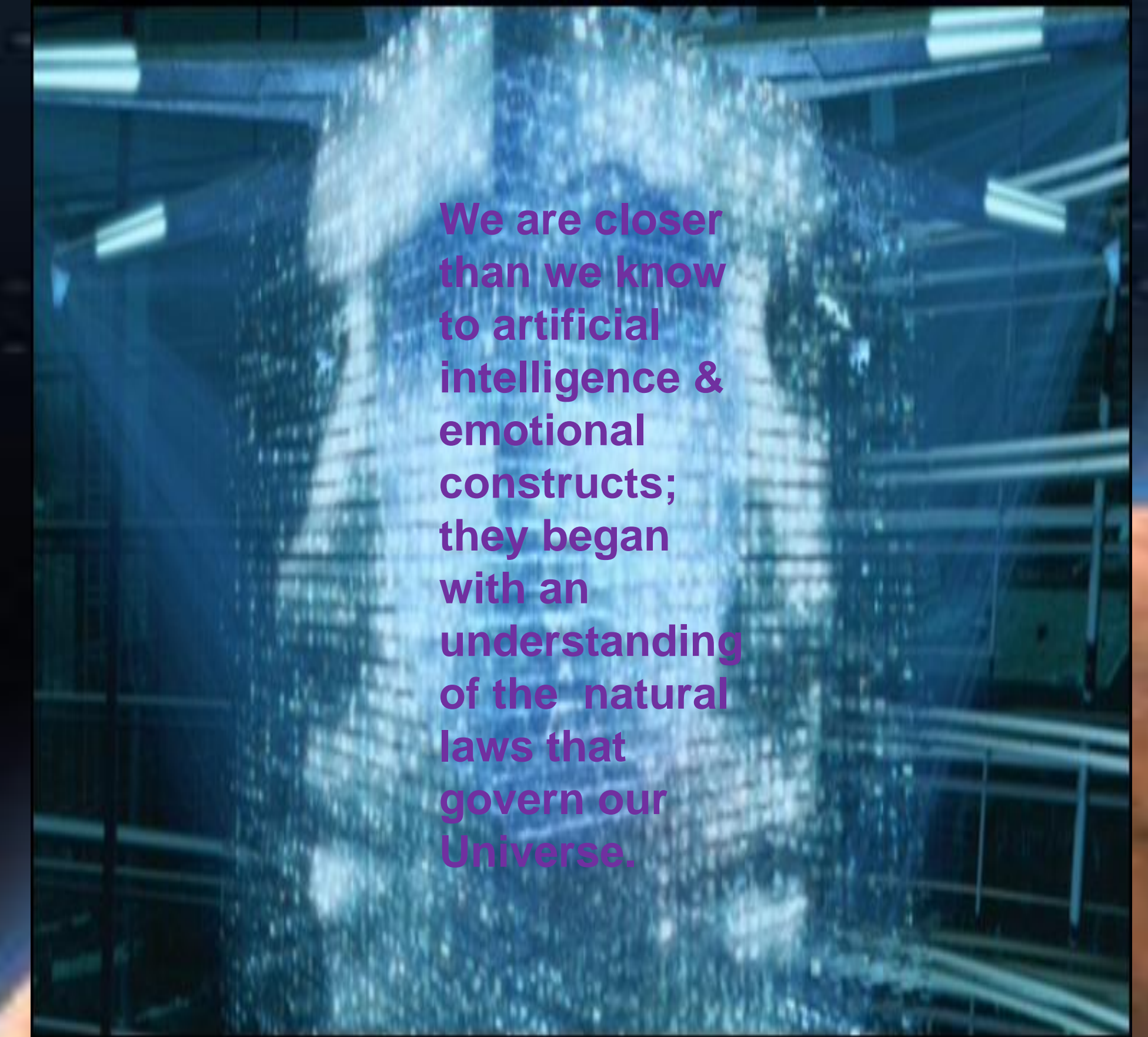
We are closer than we know to artificial intelligence & emotional constructs; they began with an understanding of the natural laws that govern our Universe.

Conclusion

$$F_{net} = (M_{sat} \cdot v^2) / R \qquad I = \int_a^b y^2 \rho \omega(y) dy$$

$$F=ma$$

Thanks to the ideas from ancient Greece and the math and physics that date back to knowledge formed in the middle ages we have a better understanding of planetary orbit. This led to technological advances such as satellites and the tracking of human/animal movement, called gait analysis. This summer we spent a great deal of energy merging the laws that govern motion with current applications of the science of motion. Robotic movement is no longer in its infant stage, but artificial consciousness is going through its birthing pains.

$$\mu r'' = -\frac{k}{r^2} + \frac{l^2}{\mu r^3}$$

$$\tau = \mathbf{M}(\mathbf{q})\mathbf{q}'' + \mathbf{V}(\mathbf{q}, \mathbf{q}') + \sum \mathbf{J}_i^T m_i \mathbf{g} + \sum \mathbf{J}_k^T \begin{bmatrix} -\mathbf{F}_k \\ -\mathbf{M}_k \end{bmatrix} + \mathbf{K}(\mathbf{q} - \mathbf{q}^N)$$

Acknowledgements