

11.1 Problems from Sheri Sheppard's textbook.

Please complete the following problems after reading Chapter 2 of Sheri Sheppard's textbook.

- Problem 1.6.2
- Problem 1.6.3
- Problem 2.2.4 Draw a picture of the system
- Problem 2.2.5 Draw a picture of the system
- Problem 2.2.7 Draw a picture of the system
- Problem 2.4.2 Photo-copy (or use) the table in the book.
- Problem 2.5.6
- Problem 2.5.7
- Problem 2.5.10
- Problem 2.5.11
- Problem 2.5.14
- Problem 2.5.15
- Problem 2.5.30
- Problem 2.5.32
- Problem 2.5.33
- Problem 2.5.34
- Problem 2.5.36 (a) (b)
- Problem 2.5.52
- Problem 2.5.56
- Problem 2.5.60 Create a rotation table for this problem.
Note: Do this for all problems where **you** find it useful.
- Problem 2.5.61
- Problem 2.5.70 Hint: Use dot-products and vector addition.
- Problem 2.6.30
- Problem 2.6.32
- Problem 2.6.36
- Problem 2.6.39
- Problem 2.7.16

11.2 Force concepts

41% The resultant of a set of forces is a force.

True/False

78% In the SI (metric) system, the units of force are:

Newton

78% In the SI (metric) system, the units of impulse are:

Newton * sec

58% The center of mass and center of gravity may be different points.

True/False

33% The center of mass and center of gravity of a rigid body always exists.

True/False

??% Newton's law is violated if the resultant of forces on a massless object is non-zero

True/False

??% Newton's law is violated if mass exists without the presence of force

True/False

??% For $\mathbf{F} = m\mathbf{a}$ to be valid, the m in $m\mathbf{g}$ must be exactly equal to the m in $m\mathbf{a}$

True/False

??% For Einstein's relativity to be valid, the m in $m\mathbf{g}$ must be exactly equal to the m in $m\mathbf{a}$

True/False

??% For modern string theory to be valid, the m in $m\mathbf{g}$ must be exactly equal to the m in $m\mathbf{a}$

True/False

75% All torques are moments.

True/False

61% All moments are torques.

True/False

61% The moment of a couple about a point O is equal to the moment of the couple about any other point P

True/False

11.3 Gravitational forces on a steel sphere.

The following information is relevant for the next section:

The density ρ of steel is $\rho = 8000 \text{ kg/m}^3$.

The volume V of a sphere of radius r is $V = \frac{4}{3}\pi r^3$.

The mass m of an object with uniform density is $m = \rho V$.

The *universal gravitational constant* is $G \approx 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$.

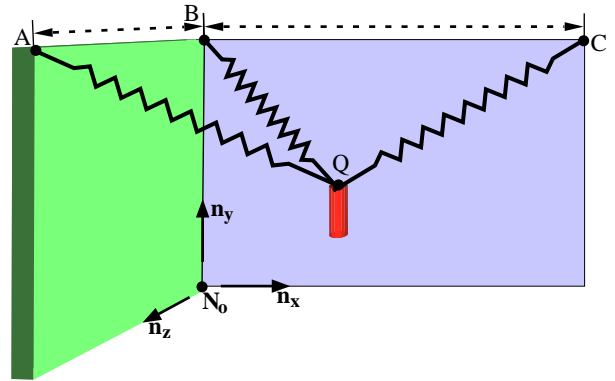


- The mass of a uniform steel sphere of radius 1 m is **33510** kg
- The average density of the planet Earth (modeled as a sphere) whose mass is $5.976 \times 10^{24} \text{ kg}$ and radius is 6371 km is **5517** kg/m^3 , which is approximately **5.5** times as dense as liquid water and **0.7** times as dense as steel.
- The magnitude of the gravitational force exerted by two uniform steel spheres of radius 1 m that are separated by 1 m (their centers are 3 m apart) is **0.008** Newtons.
- The magnitude of the gravitational force exerted by the Earth on a uniform steel spheres of radius 1 m that is 1 m above Earth's surface is **329079** Newtons.
- The ratio of the magnitudes of Earth's gravitational force on a sphere to the gravitational force of a sphere on another sphere is approximately **39.5** million.
- Earth's gravitational forces are **strong**/weak.
- A human infant can overcome Earth's entire gravitational force on a bottle or toy. Gravitational forces are **strong**/**weak**.

11.4 Statics for a suspended microphone

A heavy microphone Q is attached to pegs A , B , and C by three light flexible cables. The point of this practical problem is to determine each cable's natural length so the microphone is properly positioned.

Quantity	Symbol	Value
Local gravitational constant	g	9.8 m/sec ²
Mass of Q	m	10 kg
Distance from A to B	AB	20 m
Distance from B to C	BC	15 m
Distance from N_o to B	h	8 m
Cable diameter	d	4 mm
Cable elastic modulus	E	2×10^9 n/m ²
\mathbf{n}_x measure of \mathbf{r}^{Q/N_o}	x	5 m
\mathbf{n}_y measure of \mathbf{r}^{Q/N_o}	y	7.7 m
\mathbf{n}_z measure of \mathbf{r}^{Q/N_o}	z	9 m
Natural length of cable \overline{AQ}	L_n^A	?? m
Natural length of cable \overline{BQ}	L_n^B	?? m
Natural length of cable \overline{CQ}	L_n^C	?? m



- (a) Find an analytical expression for k (a cable's spring constant) using the fact that for a linearly elastic material with elastic modulus E , cross sectional area A , and natural length L_n , a cable's stretch δ is related to the tension F in the cable by $\delta = \frac{F L_n}{AE}$.

Result:

$$k = \frac{AE}{L_n}$$

- (b) Determine L_n^A , L_n^B , and L_n^C using the fact that for static equilibrium the resultant force on Q is zero, i.e., $\mathbf{F}^Q = \mathbf{0}$. Assume each cable acts as a linear spring, e.g., the force on Q from the spring connecting A to Q is written in terms of its linear spring constant k_A , its stretch (defined in terms of the difference between its length L_A and natural length L_n^A), i.e., $stretch \triangleq L_A - L_n^A$. and the unit vector \mathbf{u} directed from A to Q as

$$\mathbf{F}^{Q/A} = -k \text{ stretch } \mathbf{u} = -k (L_A - L_n^A) \mathbf{u}$$

Note: Consider using Autolev or Matlab and submit a printed copy of your Autolev or Matlab file.

Result:

$$L_n^A = 11.29 \text{ m} \quad L_n^B = 10.01 \text{ m} \quad L_n^C = 12.72 \text{ m}$$

- (c) Comment on the difficulty in solving this "simple" problem of determining the static equilibrium position of a particle hanging on three springs. This problem is not as "easy" as it appears.
- (d) Discuss other engineering considerations for safely hanging the heavy microphone.

Result:

Material properties (e.g., yield strength and rust characteristics) and manufacturing imperfections. Factor of safety for dynamic loads (which may be much larger than static loads).