11.8 Statics: Free-body diagram of a diver and diving-board

The following figure shows a diver D standing still at the distal end of a relatively-rigid, uniform-density, horizontal diving board B. The diving board is supported by a frictionless pin joint P and a vertical spring. The diving board's material properties, geometry, and supports dictate that the board will break if the magnitude of the force on B at any point exceeds 9000 N (i.e., approximately lbf or USton).

Relevant points and reference frames include

- Newtonian reference frame N
- Point B_P is the point of B in contact with P
  P is where engineers are most concerned about failure.
- Point B_S is the point of B in contact with the spring
- Point B_D is the point of B in contact with D
- Point B_{cm} is the center of mass of B
- Point D_B is the point of D in contact with B
- Point D_B is the point of D in contact with B

To facilitate this analysis, right-handed, orthogonal, unit vectors $\mathbf{b}_x$, $\mathbf{b}_y$, $\mathbf{b}_z$ are fixed in B with $\mathbf{b}_x$ pointing horizontally right from P to D_B and $\mathbf{b}_y$ pointing vertically upward.

The steps in this free-body analysis are as follows:

(a) Identify a system S
(b) Identify the external **contact** and **distance** forces on S
(c) Use laws of static equilibrium, i.e, $\mathbf{F}^S = \mathbf{0}$ and $\mathbf{M}^{S/P} = \mathbf{0}$.
(d) Form scalar equations and solve.

The diving board B as system S

Since failure is expected to occur at point B_P, one choice of a system is diving board B.

- Identify the external **contact** and **distance** forces on B
  –
  –
  –
  –
  –
- Write the resultant force on B as a sum of forces.
  Set the resultant force on B to $\mathbf{0}$.

$$\mathbf{F}^B = \underline{\qquad\qquad}$$

$$\mathbf{F}^B = \underline{\qquad\qquad} = \mathbf{0}$$

- Write the moment of all force on B about a point (you choose it) as a sum of moments.
  Set the moment of all forces on B to $\mathbf{0}$.

$$\mathbf{M}^{B/\square} = \underline{\qquad\qquad}$$

$$\mathbf{M}^{B/\square} = \underline{\qquad\qquad} = \mathbf{0}$$

- Form relevant scalar equations

The diver D as system S

Since the contact force between the diver and the board is an unknown, it may make sense to choose the next system as the diver D.

- Identify the external **contact** and **distance** forces on D
  -
  -
  -
  -
  -
- Write the resultant force on D as a sum of forces.
  Set the resultant force on D to $\mathbf{0}$.

$$\mathbf{F}^D = \underline{\qquad\qquad}$$

$$\mathbf{F}^D = \underline{\qquad\qquad} = \mathbf{0}$$

- Form relevant scalar equations

$$\underline{\qquad\qquad}$$

The diving board B and the diver D as system S

Another choice of a system is both the diving board **and** the diver D. One advantage of choosing BD as a system is that the contact force between the diver and the board is now an ***internal force***!

- Identify the external **contact** and **distance** forces on BD
  -
  -
  -
  -
  -
- Write the resultant force on BD as a sum of forces.
  Set the resultant force on BD to $\mathbf{0}$.

$$\mathbf{F}^{BD} = \underline{\qquad\qquad}$$

$$\mathbf{F}^{BD} = \underline{\qquad\qquad} = \mathbf{0}$$

- Write the moment of all force on BD about a point (you choose it) as a sum of moments.
  Set the moment of all forces on BD to $\mathbf{0}$.

$$\mathbf{M}^{BD/\quad} = \underline{\qquad\qquad}$$

$$\mathbf{M}^{BD/\quad} = \underline{\qquad\qquad} = \mathbf{0}$$

- $\underline{\qquad\qquad}$

  $\underline{\qquad\qquad}$

  $\underline{\qquad\qquad}$