Modelling of lifting of Dragon Capsule after splash down - problem formulation Exercise 0

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Dragon series is one of the most important missions of SpaceX for launching humans into space. Our objective is to model the recovery operation of the dragon capsule when it is lifted using a crane and analyse the structural performance of the crane.

I. INTRODUCTION

SpaceX is one of most successful private space companies in the world. The SpaceX Dragon is a reusable spacecraft designed by SpaceX used to transport humans to and fro space. It is capable of carrying 7 passengers.[1]. The spacecraft is launched using a Falcon 9 launch vehicle that is designed and operated by SpaceX.

The latest iteration is the Dragon 2 spacecraft. It successfully carried a first flight of astronauts in 2020 to International Space Station (ISS). Fig. 1 shows the dragon spacecraft. Tab. I shows the overview of the dragon spacecraft.

FIG. 1. The Dragon Spacecraft [1]

The spacecraft consists of two parts - the trunk and the capsule.

Trunk: Dragon's trunk supports the spacecraft during ascent and carries unpressurized cargo. One half of the trunk is covered in solar panels that provide power to Dragon during flight and while on-station.

Height	8.1 m
Diameter	4 m
Capsule volume	9.3 m^3
Trunk volume	37 m^3
Launch payload mass	6000 Kg
Return payload mass	3000 Kg

TABLE I. Overview of Dragon spacecraft [1]

The trunk remains attached to the capsule until shortly before re-entry. [1]

Capsule: The Dragon capsule enables the transport of people as well as sensitive cargo. The capsule is equipped with 16 Draco thrusters for attitude control of the capsule in orbit and 8 SuperDraco thrusters that power the spacecraft's launch abort and escape system [1]. Fig. 2 shows the dragon capsule.

FIG. 2. The Dragon Capsule [1]

During re-entry, the capsule deploys two drogue parachutes first to stabilize the descent and deploys four main paarachutes for full-fledged deceleration before splash-down into the ocean. The capsule is located by GO searcher and secured by GO navigator (both ships are used as recovery ships by SpaceX) and is lifted and

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placed into the nest that is onboard the GO navigator after which the astronauts exit the capsule. The GO navigator uses a A-frame crane to do the lifting. Fig. 3 shows the GO navigator and Fig. 4 shows it with the dragon capsule. Fig. 5 shows the recovery of the dragon capsule containing astronauts, Bob and Doug, using the A-frame crane onboard GO navigator. Fig. 5 shows the capsule and the crane on the GO navigator.

Our interest lies in modelling the A-frame crane that lifts the capsule on to the GO navigator.

FIG. 3. The GO navigator vessel [2]

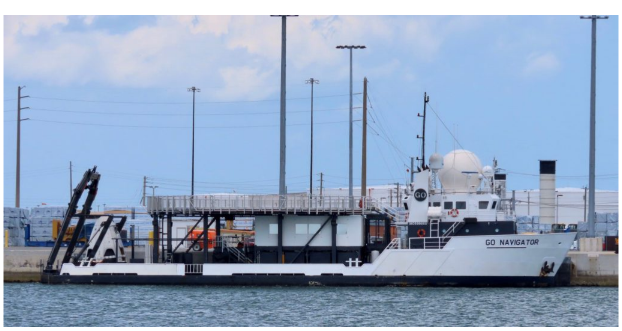

FIG. 4. The GO navigator vessel alongwith the dragon capsule [2]

FIG. 5. Dragon capsule lifted aboard GO Navigator with Bob and Doug - NASA Kennedy [2]

FIG. 6. Dragon capsule and the A-frame crane [2]

II. PROBLEM FORMULATION

Our problem of interest is to identify and analyze the mechanical stresses and strains on the crane that lifts the Dragon capsule by developing a suitable model. We simplify the crane and model it as a one-DOF four-bar linkage mechanism that carries a pendulum load (the crew capsule) at the tip of the four-bar. The mechanism is actuated at the middle of the first link using a hydraulic piston. The height of suspension of the pendulum is assumed to be 2.5x of the height of the crew capsule which is approximately 10 metres. The width in third dimension is assumed to three-fourth of the width of the deck (which is 11 metres) which is approximately 8 metres. The height of the four-bar is assumed to be 7 metres and the width is assumed to be 6 metres. The length of the pendulum is assumed to be 7 metres. The links in the structure are assumed to be rigid and the links are connected by roller joints in the four-bar and the actuator is assumed to have a prismatic joint. Mass of the capsule is found to be 3000 Kg from Tab. I. Figs. 7, 9 and 8 show the model with the assumed dimensions.

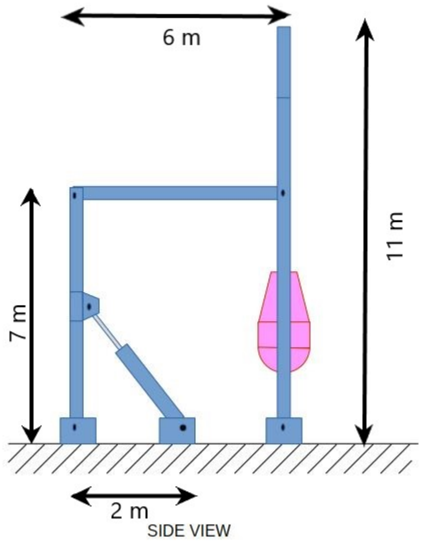

FIG. 7. The side view of the model with dimensions

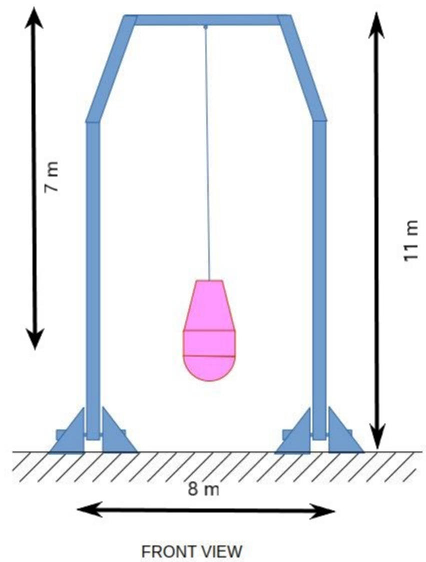

FIG. 8. front view of the model with dimensions

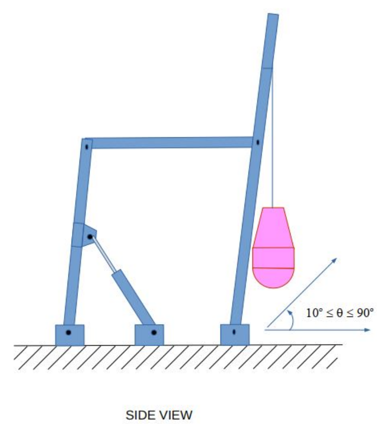

FIG. 9. The side view of the model actuated

III. CONCLUSIONS

The model which is to be used for analysing the structural performance of the crane is outlined. The dimensions are approximated from the images and are subject to change as the analysis proceeds.

[1] SpaceX website-Dragon ().
[2] Spacexfleet.com ().