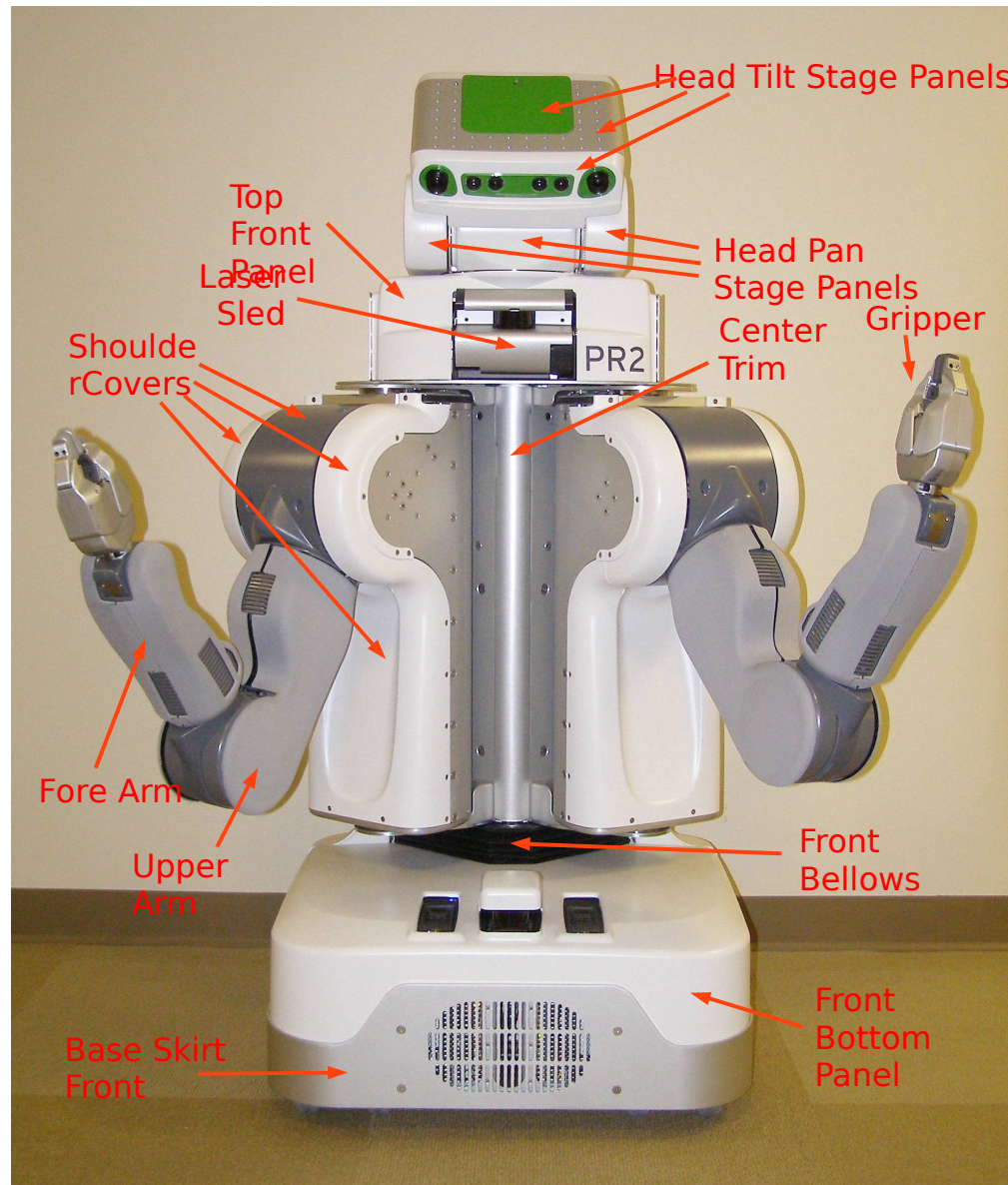# PR2 Maintenance

ROS + PR2 Training Workshop

PR2 Maintenance Overview

- PR2 overview

- Review electrical and ESD safety

- Review PR2 power system

- PR2 accessory kit

- PR2 tool kit

- Hands on demos

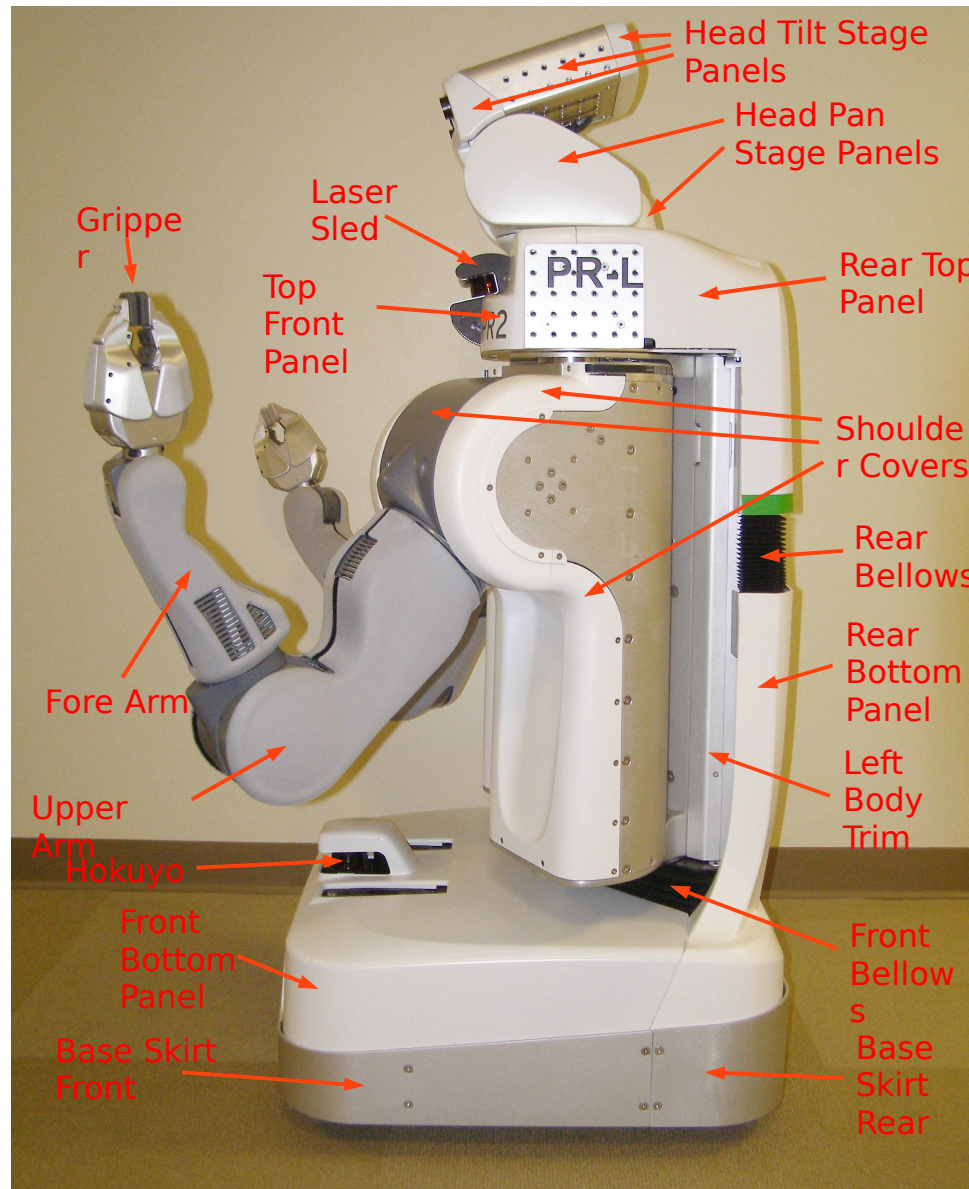- See *support.willowgarage.com* to order replacement parts

PR2 Overview

- PR2 "anatomy"

- Hands-on demos

  - Filter maintenance

  - Gripper tip replacement

  - Counter balance adjustment

- Points of interest

  - Power switch

  - A/C breaker

  - Run-Stop button
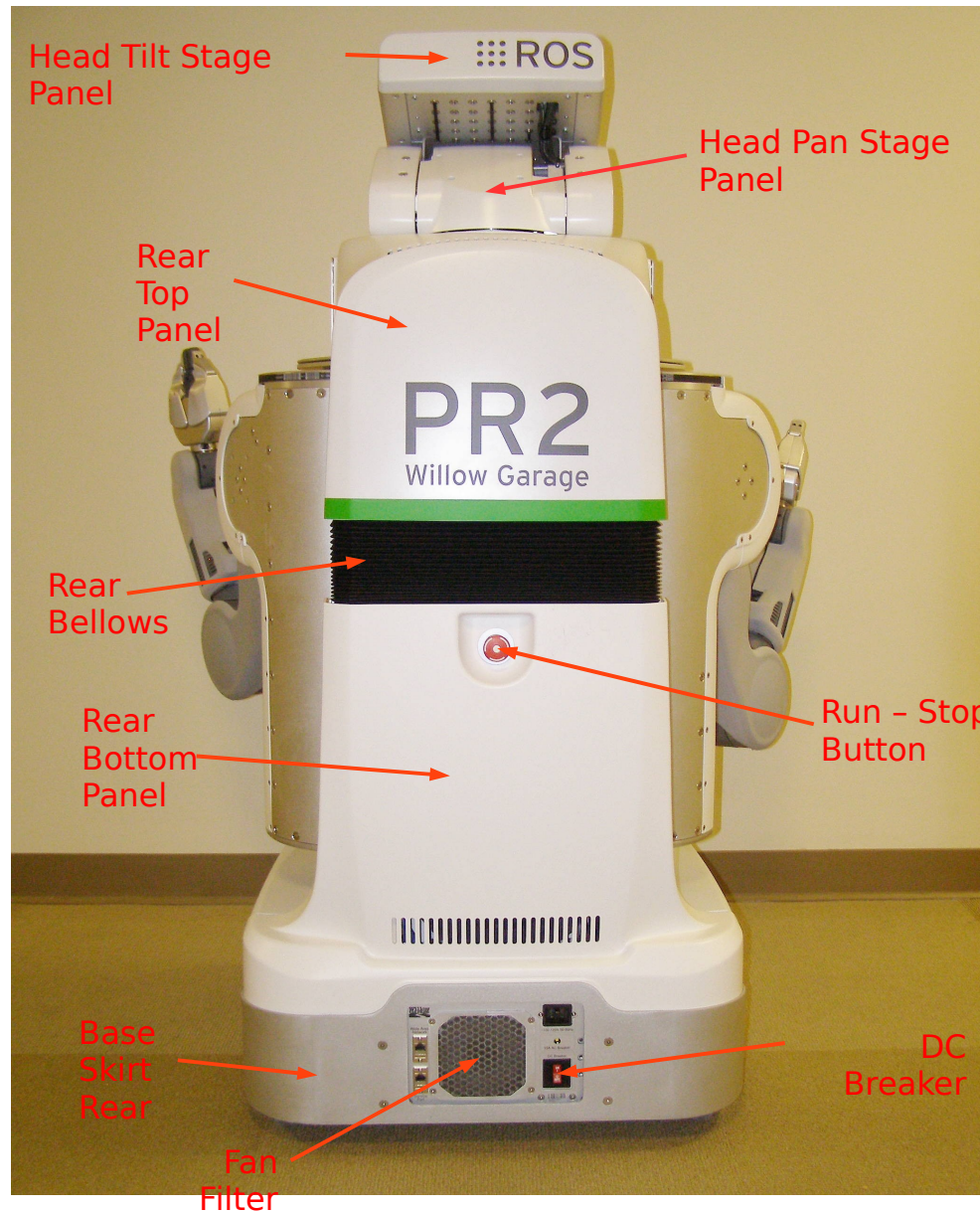
  - Plug for the ESD strap

PR2 Front View

PR2 Side View

PR2 Rear View

Head Tilt Stage Panel

Head Pan Stage Panel

Rear Top Panel

Rear Bellows

Rear Bottom Panel

Run – Stop Button

Base Skirt Rear

Fan Filter

DC Breaker

Electrical and ESD safety

- When performing maintenance:

    - Turn off power even when removing covers

        - The only exceptions are when performing counter balance adjustments and replacing the fan filter

    - Disconnect AC power to the PR2

    - Always use an ESD strap

- ESD straps are provided in the accessory kit:

    - Place strap around bare wrist

    - Plug jack into accessory panel

PR2 Power System

PR2 internal power precautions and safety features:

- Battery power is "live" within the robot, *even when the power is off*

- The power board controls all the power to the PR2 systems and is accessible/controllable via the ROS pr2_power_node

- There are as many as 7 levels of protection but you cannot assume they will prevent damage or injury

- Always turn off the PR2 power when performing maintenance except when specifically required to complete a procedure such as the counter balance adjustment

PR2 Power Requirements

Wall power:

- The PR2 can only be plugged into a dedicated 15A **minimum** circuit

- Only use the supplied power cord

- Only use the supplied self plug-in cord

- See support.willowgarage.com for ordering replacement cords

Battery runtime

- Approximately 2 hours stationary, less when moving

PR2 Accessory Kit

15 FT power cord 68-06167

Self plug-in cord 68-06153

Joystick 68-02985

Hard drive bay keys 68-03337

Wireless run-stop 68-01059

USB joystick cable 68-03533

Small Checkerboard 68-03823

Fan filters 68-02802 (x5)

ESD strap 68-03024

Base station recovery DVD

User manual

Gripper tips box:

Sensor fingertips 68-03840 (x5) (use only with boots!)

Fingertip boots 68-03347 (x20)

PR2 Tool Kit (1)

Counter balance adjustment rod - 10mm hex 68-07034

Counter balance adjustment tube 68-07147

Ratchet head bits:
    1.5mm 68-07040
    2.5mm 68-07042

Driver bits:
    1.5mm 68-07062
    2.0mm 68-07063
    2.5mm 68-07064
    2.5mm ball end 68-07059
    3.0mm 68-07065
    4.0mm 68-07066
    5.0mm 68-07067

Needle nose pliers 68-07112

Diagonal Cutter 68-07146

Zip-ties 68-07150

1/4 sq. male to 1/4 hex male 68-07075
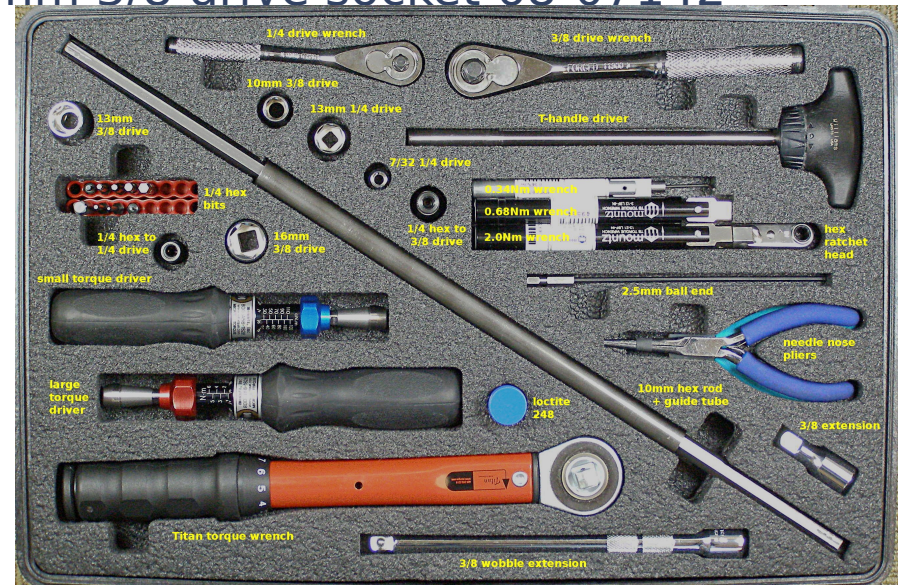
1/4 sq. drive to 1/4 hex female 68-07077

3/8 sq. drive to 1/4 hex female 68-07078

10mm 3/8 drive socket 68-07079

13mm 1/4 drive socket 68-07085

13mm 3/8 drive socket 68-07086

16mm 3/8 drive socket 68-07142

PR2 Tool Kit (2)

7/32 1/4 drive socket 68-07090

3/8 drive short extension, 68-07116

3/8 drive wobble extension, 68-07118

1/4 drive quick release extension, 68-07140

1/4 drive flex joint, 68-07141

1/4 drive ratchet wrench, 68-07138

3/8 drive ratchet wrench, 68-07139

Needle Nose pliers, 68-07112

Mountz wrench and driver tools:

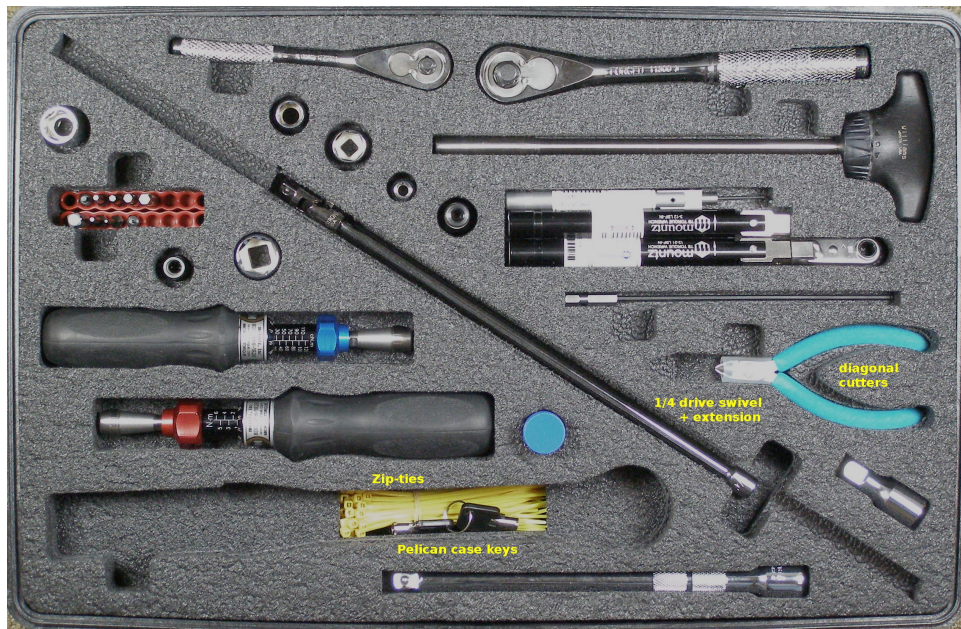 Fixed 0.34Nm wrench, with 1.5mm right angle Allen, 68-07025

  Fixed 0.68Nm wrench, 68-07028

  Fixed 2.0Nm wrench, 68-07029

  1/4 hex ratchet head, 68-07033 (for use with 0.68 ans 2.0 Nm wrenches)

  0.20 – 1.20 Nm torque tool, 68-07014 (small)

  1 – 6 Nm Torque tool, 68-07015 (large)

diagonal cutters

1/4 drive swivel + extension

Zip-ties

Pelican case keys

Using Torque Tools

Small and large driver

Special stack-ups

See support.willowgarage.com:

PR2 Toolkit: Setting Torque Driver
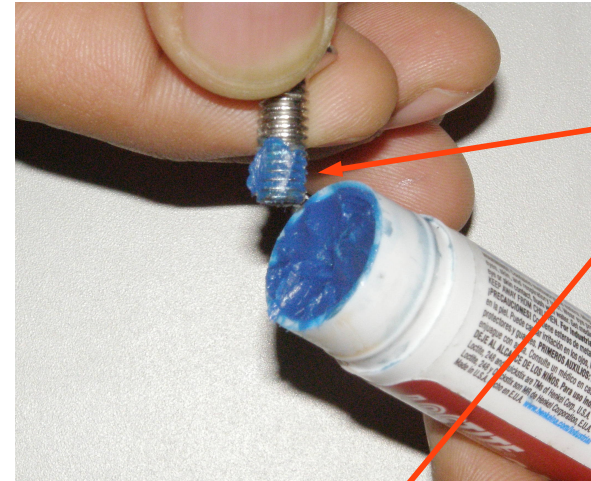

Blue Adjustment Nob – Small Torque Driver

Red Adjustment Nob – Large Torque Driver

0.34 Nm

1.36 Nm (1.4)

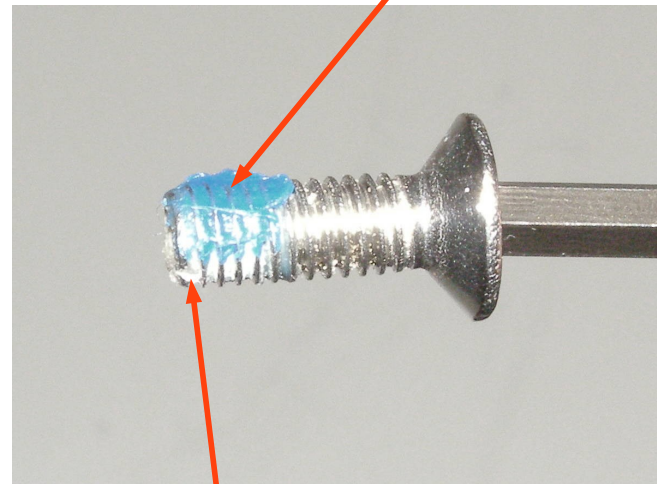Rotate to adjust torque

Adjustment

Rotate

11.0 Nm
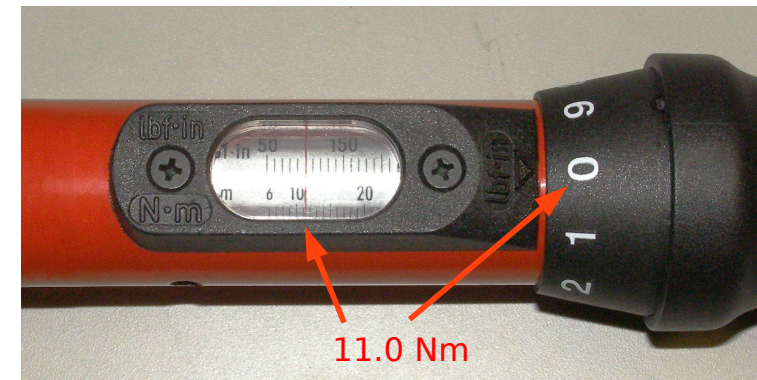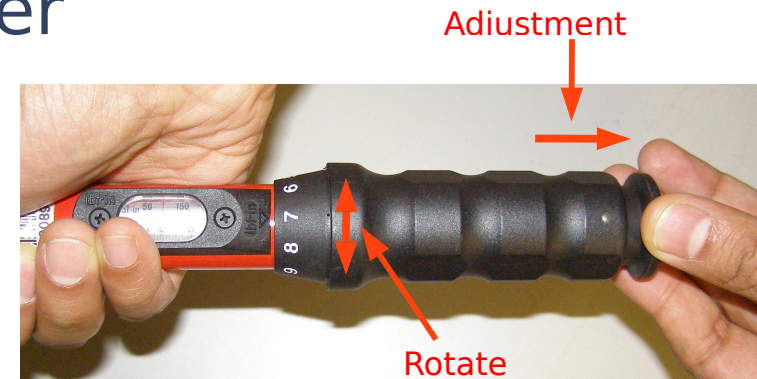
Using Loctite

- Use Loctite to retain fasteners and keep them from vibrating loose

- There is no need to clean the old Loctite

- The fresh Loctite will integrate with the old

Only a small "patch" of Loctite is needed.

Old Loctite.

Today's Demos

Video of gripper tip replacement

Live demo of fan filter repair/replacement

Hands-on demo of counterbalance adjustment

See **support.willowgarage.com** for all maintenance procedures
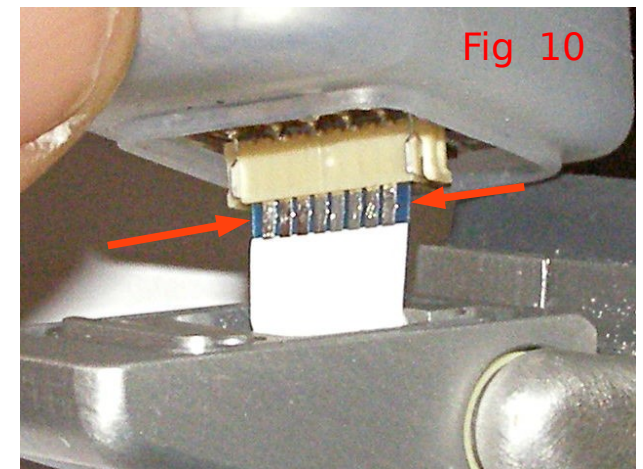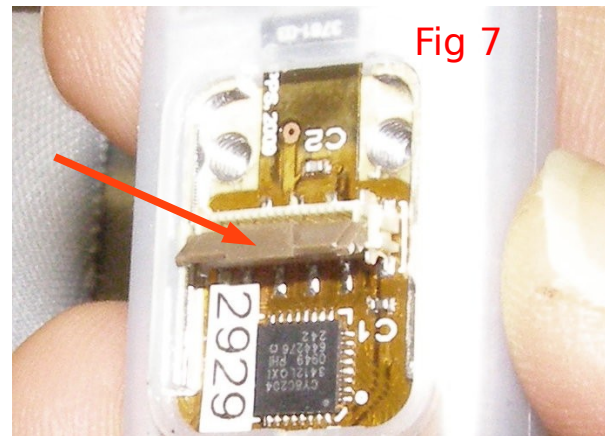
Gripper Tip R/R Video

Turn off power

Wear ESD strap

Always cover sensors with boots

Replace boots as soon as they show signs of damage

Willow Garage will not replace damaged sensor tips

See support.willowgarage.com for replacements

Fig 6

Fig 7

Fig 10

Fan Filter Demo

Clean regularly every 1-4 weeks

Clogged filter will cause fan speed to increase (noisy robot)

Vacuuming filter is not recommended since this may tear the filter

Maintenance:

Remove the filter cover plate

Wash and **dry** filter

Having the fan on helps when placing the filter

Re-install the cover plate

Counter Balance Review

Overview: PR2 counter balance (CB) holds up the weight of the arms using a spring and pulley system

Goal: The CB should balance the arm so that almost no torque is required to maintain position of the arm

Performance: A well adjusted counter balance will maximize the performance of the PR2 arm controllers

CB Adjustment Overview

With time, the springs of the CB system can start to sag or give. To maintain performance, you will have to *adjust* the mechanism.

- Secondary spring can be stiffened or loosened
    - Clockwise (CW) turns increases force on arm
- "Arm gimbal shaft" controls level arm length of CB spring force
    - Counterclockwise (CCW) increases force on arm

Fig 1

Right

Secondary Spring

Arm Gimbal Shaft
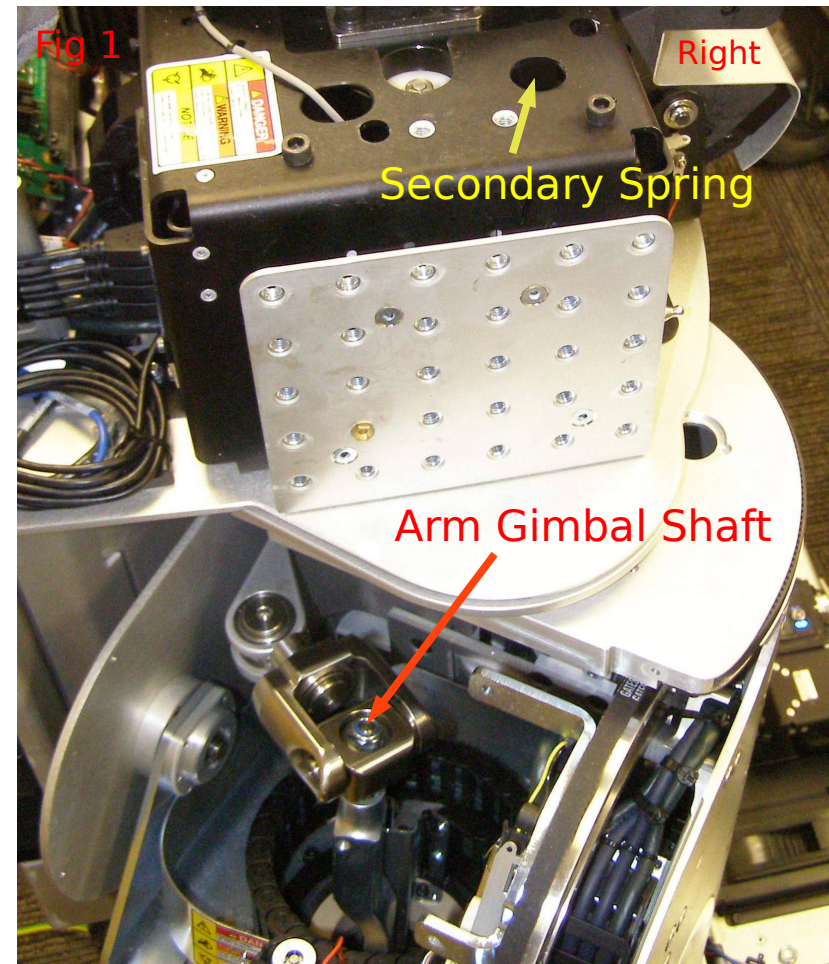
CB Adjustment Demo

- Demonstrate checking and adjusting the counterbalance on the PR2

  - We will demonstrate up front

  - You will adjust your own counterbalance with help from Willow Garage engineers and technicians

Notes:

Safety first

You need two people to adjust the mechanism

Observe ESD protocol (wrist strap)

Watch for pinch points

CB Check Program

- We use a counterbalance adjustment/check program to adjust the counterbalance.

  - The program moves the arm of the robot and measures the torque on each joint

  - It uses training data to recommend adjustments to for a minimum torque setting

    - The program is an iterative solver, in some cases more than one iteration is required

You will run the check program and determine your required adjustment.
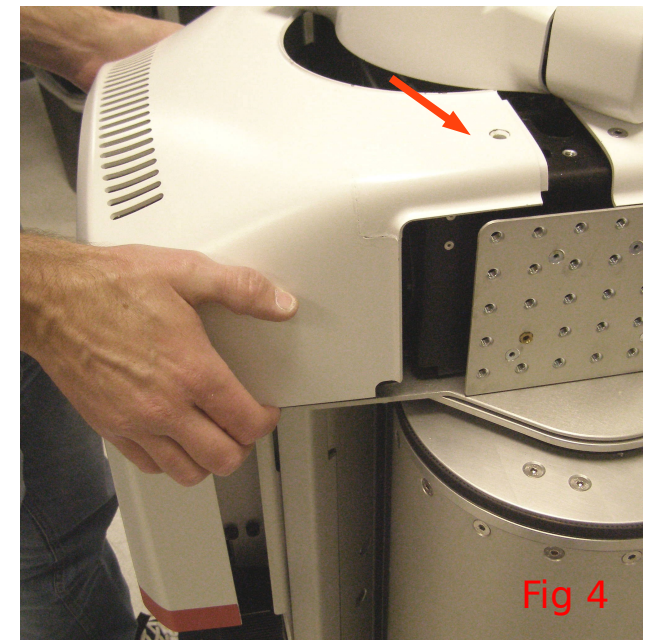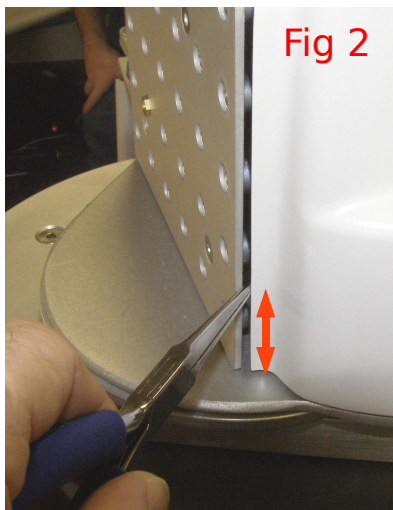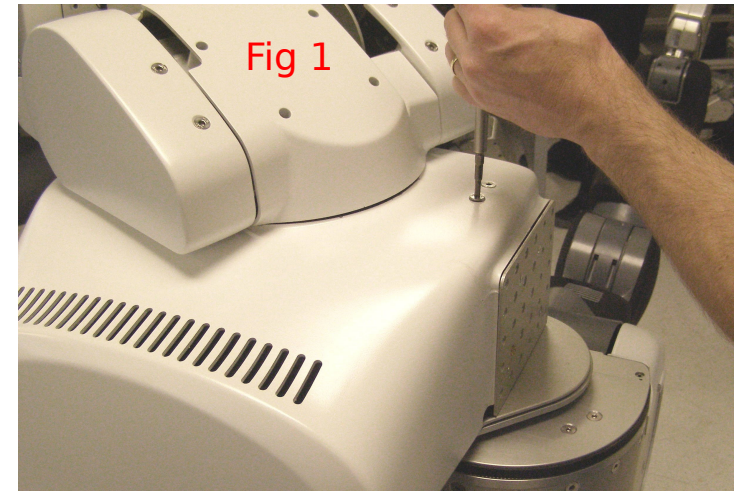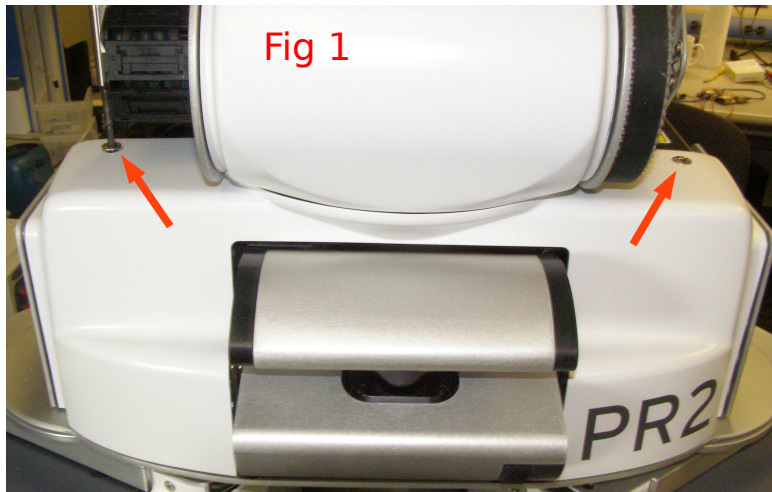
CB Check Program Install

Counterbalance adjustment program is *unreleased*.

- You will have to install it from wg-ros-pkg trunk and build it

- Tutorial:

  - ros.org/wiki/qualification/Tutorials

- Follow tutorial instructions to install and build

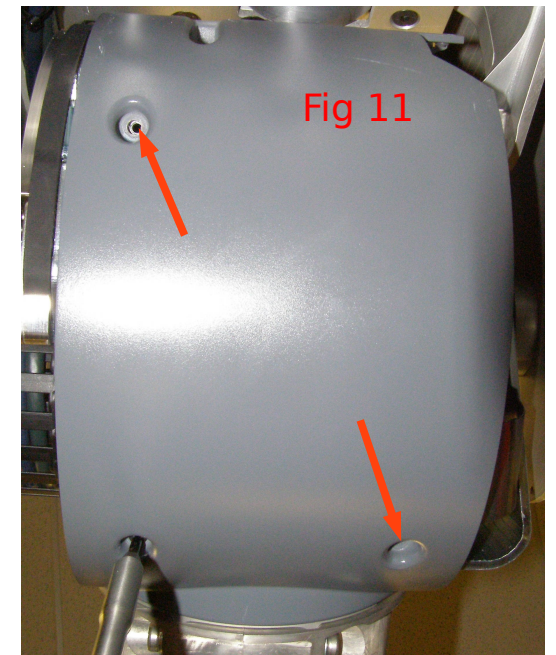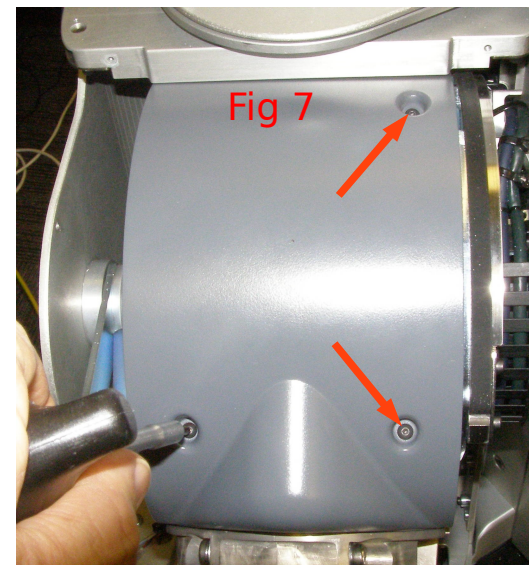**Important:** Do not start the CB adjustment program until instructed to do so
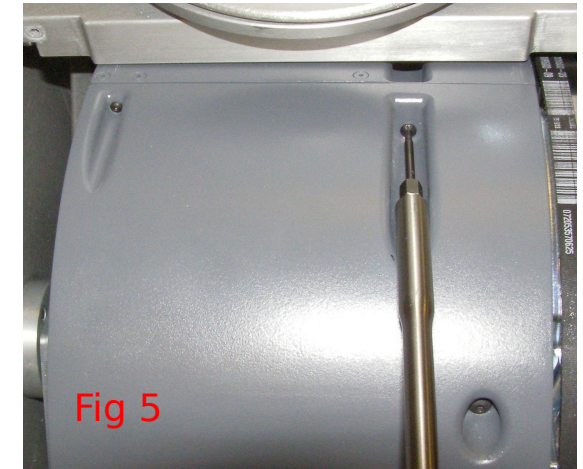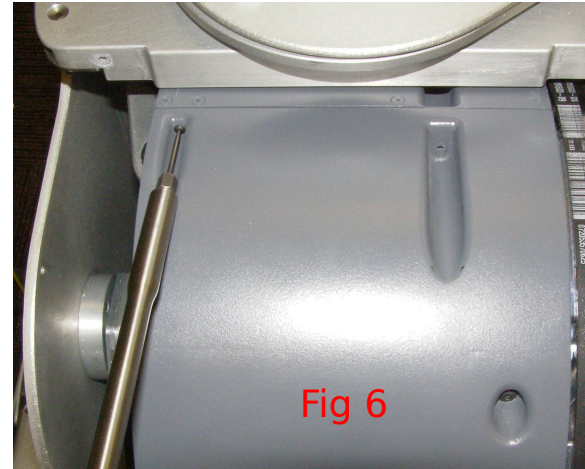
CB Adjustment Demo

Observe safety and ESD protocols.
Remove top covers, Doc6

Fig 1

Fig 1

Fig 2

Fig 3

Fig 4

CB Adjustment Demo

Observe safety and ESD protocols.
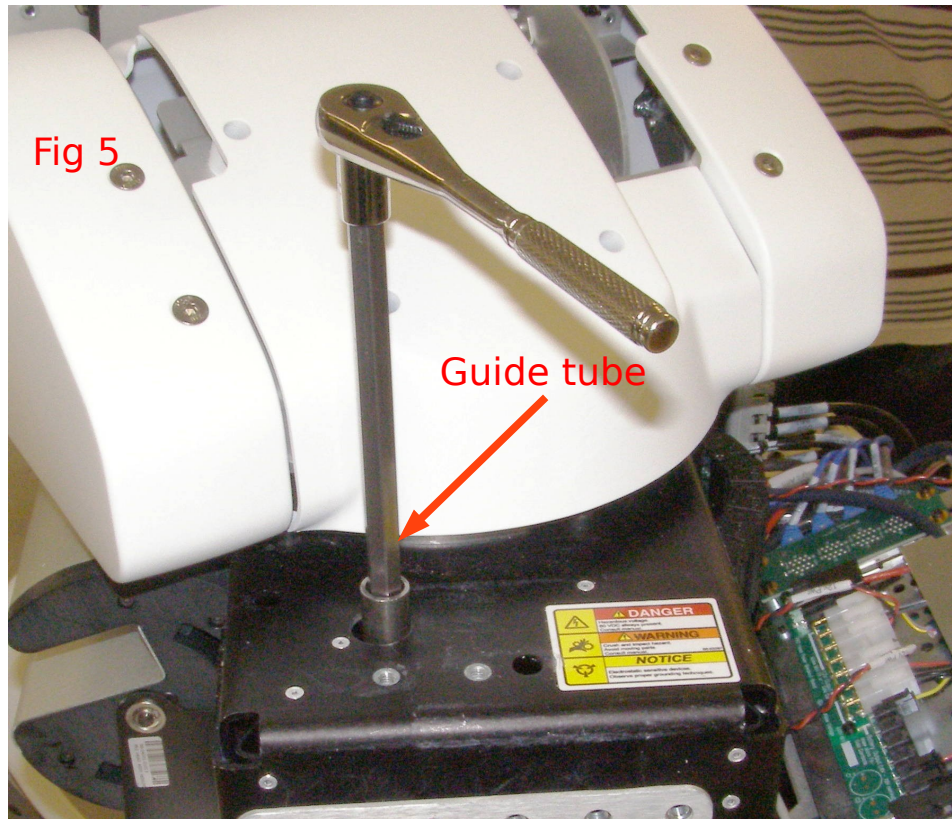
Remove shoulder covers, Doc16

Fig 6

Fig 5

Fig 7

Fig 11

CB Adjustment Demo

Adjust counter balance, Doc5

Re-run the Check program and adjust the CB if needed, Doc5

Re-install the covers, Doc6

Fig 5

Guide tube

Fig 6

CB Adjustment Procedure

Check CB with adjustment program

 Clear out 2m space around your robot

Turn robot off (*sudo pr2-shutdown*)

Remove covers

 Ask your Willow Garage helper for questions

Adjust CB

 Make adjustments check tool recommends

Turn robot on

Check CB with adjustment program

Turn robot off

Reinstall covers

Remember!

Safety First

support.willowgarage.com

Always wear an ESD wrist strap

Don't be afraid to ask questions

Questions?????