Question 1:

a) So for the book, the only forces acting are:
F_N - Normal Force from table
F_g - Gravitational force (weight)

b) For the table we have:
F_N - Normal Force from ground
F_g - Gravitational force of table
F_g - Gravitational force of book

c) No. The action-reaction pair for the book is the two forces between the Earth itself and the book. The normal force on the book has a reaction pair on the table as the force the book exerts on the table.

d) For the stringed book:
F_g - Gravitational force (weight)
F_T - Tension in the rope pulling upward

*Notice there's no normal force in d) because the book is virtually not touching the table

Question 2:

Idea:
The acceleration of the rocket will make the astronaut appear lighter than normal. This is because the rocket's acceleration is against gravity! So if we figure out the acceleration of the rocket, we know that the astronaut also experiences this force and can figure out his weight by subtracting his downward acceleration from his upward acceleration.

Setup & solution

The Net Force acting on the astronaut must be:

$\vec{F}_{net} = \Sigma\vec{F} = \vec{N} - \vec{W} = m\vec{a}_{net}$

(a) Since we want their apparent weight, we need to know how much force they are exerting on the chair that holds them in place. That means we need their **Normal Force**:

$$N = m\vec{a}_{net} + \vec{W}$$

Since we know W=mg, we need to get the net acceleration of the astronaut, which is the rocket's acceleration. We use kinematics to do this:

Y
$V_f = 15$ m/s
$V_o = 0$m/s
$a = a_{net}$
$t = 15s$
$\Delta y = ?$

So based off our chart we use:

$$V_f = V_o + a_{net}t$$

Which we can rearrange to:

$$a_{net} = V_f/t$$

Inserting this yields our final expression:

$$N = \frac{mV_f}{t} + mg = m(\frac{V_f}{t} + g) \approx \boxed{730\text{N}}$$

(b)

$$W = mg \approx \boxed{560\text{N}}$$

Question 3:

Idea:
This is a direct use of Newton's law of Gravitation and Newton's 2nd law. The acceleration due to gravity is just the net force acting on an object due to its mass. If the mass has no other accelerations on it, then the net acceleration is the acceleration due to gravity. We can get the centripetal acceleration directly after that.

Setup & solution

(a)

$$\vec{F}_{net} = F_g = \frac{GM_{earth}m_{sat}}{r^2} = m_{sat}\vec{a}_{net}$$

Thus we solve for the net acceleration:

$$a_{net} = \frac{GM_{earth}}{r^2}$$

Since r is the distance from the center of earth to the satellite:

$$r = R_{earth} + 3.6 \times 10^7 m$$

Thus

$$a_{net} = \frac{GM_{earth}}{(R_{earth} + 3.6 \times 10^7 m)^2} \approx \boxed{0.222 \text{ m/s}^2}$$

(b)

$$a_c = \frac{v^2}{r} \implies v = \sqrt{a_c r} = \sqrt{(0.22 m/s^2)(R_{earth} + 3.6 \times 10^7 m)} \approx \boxed{3070 \text{ m/s}}$$

Question 4:

Idea:
This is a problem that marries the ideas of apparent weight and frictional force. Since the friction force is proportional to the normal force, it should be affected when the elevator accelerates because we know the normal force changes when the elevator moves. This normal force is the apparent weight of the box.

Setup & solution

In the **X**-direction:

$$\vec{F}_f = -\mu_k N$$

(*Minus sign because friction always opposes the direction of motion, which is natural to be the positive direction)

To get normal force we sum the forces in the Y-direction:

$$F_{netY} = N - W = ma_{net} \implies N = W + ma_{netY} = m(g + a_{netY})$$

Inserting this in for F_f:

$$F_f = -\mu_k m(g + a_{net_Y}) = -\mu_k m(g + a_{net_{elevator}})$$

(a) If stationary $a_{netY} = 0$ so

$$F_f = -\mu_k mg = -(0.4)(59kg)(9.81\frac{m}{s^2}) \approx \boxed{\text{-232N}}$$

(* Notice we don't put the negative sign on g because we already accounted for it in the F_{net} equation)

(b) If accelerating upward at 2 $\frac{m}{s^2}$:

$$F_f = -\mu_k m(g + a_{netY}) = -(0.4)(59kg)(9.81 + 2.0\frac{m}{s^2}) \approx \boxed{\text{-279N}}$$

(c) At first when the elevator is moving, we need to overcome the frictional force of $F_f = -279N$. But the person is only applying a force of 250N! So the box won't move. If we have the elevator not moving, suddenly we only need to overcome $F_f = -232N$ of force, which we can overcome!

Question 5:

Idea:
This is a problem is quite silly, but it holds good physics regardless! We have a situation basically where two giant spheres are colliding. You can think of it where the black hole will stay still while the earth will move towards it. We use Newton's laws to get our acceleration then use kinematics to figure out the time.

Setup & solution
(a) Since we have a body starting from rest and moving a distance, we use kinematics to figure out time:

Radial direction
$V_f =?$ m/s
$V_o = 0$m/s
$a =?$ (*We can get this from gravitational acceleration)
$t =?$
$\Delta r = R_{au}$

So, we look for a kinematic with time,acceleration, initial velocity and distance:

$$\Delta r = V_o t + \frac{1}{2}at^2 \implies t = \sqrt{\frac{2\Delta r}{a}} = \sqrt{\frac{2\Delta R_{au}}{a}}$$

Since we don't know a, we solve for it using:

$$\vec{F}_{net} = F_g = \frac{GM_\odot M_{Earth}}{r^2} = M_{Earth}a_{net} \implies a_{net} = \frac{GM_\odot}{r^2} = \frac{GM_\odot}{(R_{au})^2}$$

Putting this all together we get:

$$\boxed{\text{t} = \sqrt{\frac{2(R_{au})^3}{GM_\odot}} \approx 82.3 \text{ days}}$$

Question 6:

Idea: This situation is the description of the "Spaceship-3000" ride that you see at amusement parks or in "Stranger Things". The main idea is that the person experiences a force balance between the wall. The two forces acting on them are the normal force of the wall and the centripetal force of the ride. But for this problem we don't need to worry about the normal force, instead we just relate the linear speed of the ride to the acceleration of the person.

Setup & solution

The only force (acting radially) is the centripetal force of the person. So we have:

$$F_{net} = F_c = ma_{net} = ma_c = m\frac{v^2}{r}$$

We desire the radius so lets solve for it:

$$r = \frac{mv^2}{F_c}$$

Thus, since the person feels the 560N force against their back, that means F_c must be this force. It's the only force they experience radially. We plug in numbers:

$$r = \frac{mv^2}{F_c} = \frac{(83kg)(3.2m/s)^2}{560N} \approx \boxed{1.52\text{m}}$$