Question 1a) [30%]

Grade	Score	Description
B	10.0	Correct
I	9.5	Correct; minor errors in labelling of forces
L	8.7	Magnitude of $\boldsymbol{F}_{\textbf{string on Fei}}$ or $\boldsymbol{F}_{\textbf{Earth on Fei}}$ wrong or not given, but it is clear that the net force is toward the centre
T	7.0	Correct magnitudes, wrong direction.
M	5.0	Showed a balanced force diagram with magnitudes shown
O	4.0	Showed a balanced force diagram, but no magnitudes are written.
P	3.0	Missed either $\boldsymbol{F}_{\textbf{string on Fei}}$ or $\boldsymbol{F}_{\textbf{Earth on Fei}}$.
S	2.0	Put on additional forces.
A	1.0	Forces point in the wrong direction.
Z	0.0	Blank or essentially blank.

This was a difficult question to get completely right, although it did not involve any physics that you have not already done a **lot** of. A *good* answer would have been one that showed that the force of the string was greater than the force of the Earth, and we know this because Fei was travelling in a circle. This would earn about a B+.

An excellent answer would proceed as follows:

1. First we need to identify the forces that act on Fei. We use our normal recipe: the only things that can exert a force on her are things touching her and long range forces (gravity in this course; in general it is gravity, electric forces and magnetism). So the only forces on Fei are $\boldsymbol{F}_{\textbf{Earth on Fei}}$ (downward) and the string $\boldsymbol{F}_{\textbf{string on Fei}}$ (upward).

2. We know the directions, and the tangential force is zero (no forces act in that direction).

3. We know the magnitude of $\boldsymbol{F}_{\textbf{Earth on Fei}}$

$$\boldsymbol{F}_{\textbf{Earth on Fei}} = (55\,\text{kg})(10\,\text{m/s}^2) = 550\,\text{N (down)}$$

   We don't know the magnitude of $\boldsymbol{F}_{\textbf{string on Fei}}$ yet.

4. We know that the net force on Fei in the radial direction has to be

$$\boldsymbol{F}_{\textbf{all on Fei (radial)}} = \frac{mv^2}{r} = \frac{(55\,\text{kg})v^2}{45\,\text{m}}$$

as she is travelling in a circle of radius 45m at a speed v.
We need the speed v to get any further.

5. To find her speed, we use the conservation of energy

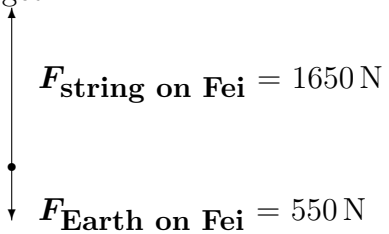
$$\frac{1}{2}m(v^2 - 0^2) + mg(0\,\text{m} - 45\,\text{m}) = 0 \Rightarrow v = 30\,\text{m/s}$$

6. With the speed, we find the net force has to be

$$\boldsymbol{F}_{\textbf{all on Fei}} = \frac{(55\,\text{kg})(900\,\text{m}^2/\text{s}^2)}{45\,\text{m}} = 1100\,\text{N} \text{ upward}$$

7. To make this the net force, we need $\boldsymbol{F}_{\textbf{string on Fei}} = 1650$ N upward.

Drawing the force diagram of Fei we get:



Question 1b) [10%]

Grade	Score	Description
L	10.0	Correct
E	9.5	Correct $\boldsymbol{F}_{\textbf{all on Fei (rad)}}$ and $\boldsymbol{F}_{\textbf{all on Fei (tang)}}$, missing directions of non-zero vectors and/or minor mistake.
I	8.0	Only $\boldsymbol{F}_{\textbf{all on Fei (rad)}}$ is consistent with part (a), direction given.
G	6.9	Only $\boldsymbol{F}_{\textbf{all on Fei (rad)}}$ is consistent with part (a), no direction given.
H	6.9	Only $\boldsymbol{F}_{\textbf{all on Fei (tan)}}$ is consistent with part (a), direction given.
T	4.0	Both components are inconsistent with part (a)
S	0.0	Blank or essentially blank

To keep the answer consistent with the first one, the net force in the vertical direction is the radial force and anything in the horizontal direction is the tangential force. **Note:** It only works this way because we are at the bottom of the circle. In part (d), the radial part is horizontal and the vertical part is tangential.

- Net radial force on Fei = 1,100 N (upward).
- Net tangential force on Fei = 0 N

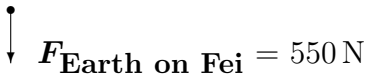
Question 1c) [30%]

Grade	Score	Description
O	10.0	Correct
U	8.5	Non-zero $\boldsymbol{F}_{\textbf{string on Fei}}$ in drawing pointing left.
C	5.0	Non-zero $\boldsymbol{F}_{\textbf{string on Fei}}$ pointing in any other direction
H	3.0	Extra forces shown
S	0.0	Blank or essentially blank

We go through a very similar process to part (a), except we know from conservation of energy that she is at rest ($v = 0$) at the top of her swing.

1. Identify that the only forces acting on her are $\boldsymbol{F}_{\textbf{Earth on Fei}}$ (downward) and $\boldsymbol{F}_{\textbf{string on Fei}}$ (to the right).
2. We know the tangential force ($\boldsymbol{F}_{\textbf{Earth on Fei}} = 550\text{N}$), and the string is the only thing responsible for the radial force.
3. We know for her to go around in a circle, the net radial force is mv^2/r. As $v = 0$, we know that the net radial force is zero.
4. This implies that $\boldsymbol{F}_{\textbf{string on Fei}} = 0$ N.

Our force diagram is now



(Note: the question did not explicitly ask for magnitudes, so if you did not give 550N as the magnitude of $\boldsymbol{F}_{\textbf{Earth on Fei}}$ then this is also acceptable for an O).

Question 1d) [10%]

Grade	Score	Description
C	10.0	Perfect
A	8.8	Correctly got $\boldsymbol{F}_{\textbf{all on Fei (rad)}} = 0$N (or whatever is consistent with part (c))
F	8.8	Correctly got $\boldsymbol{F}_{\textbf{all on Fei (tang)}} = 550$N (or whatever is consistent with part (c))
E	5.0	All wrong
S	0.0	Blank or essentially blank

Question 2a) [5%]

Grade	Score	Description
B	10.0	Perfect
L	4.0	Wrong
A	0.0	Blank or essentially blank

The net torque was zero, as they both had the same force on the seesaw and the same lever arm, but rotated the plank in opposite directions.

Question 2b) [15%]

Grade	Score	Description
Y	10.0	Selected A with correct reasoning.
O	7.5	Selected A or B with incorrect reasoning .
G	7.0	Selected C or D with incorrect reasoning.
A	1.0	Made a selection with NO reasoning
S	0.0	Blank

As there is no net torque, $\boldsymbol{\Delta} L = 0$. As $\boldsymbol{L}_i = 0$ (by the initially not moving condition), this implies $\boldsymbol{L}_f = 0$. Therefore it will not begin to rotate; instead it will stay where it was initially. Therefore the correct answer is **A**.