Unit 17 · Statics

ANSWER KEY · FOR TEACHERS

Full marks 23

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

K · 3

1. equilibrium
2. triangle
3. Lami's theorem
4. sine
5. tension
6. reaction

Each carries 0.5 mark.

2 True or false

U · 3

i. ✓ **True**

ii. ✗ **False**: They can't close a triangle: $2 + 3 < 6$, so the 6 N force is larger than the other two can balance.

iii. ✗ **False**: It is the angle **between the other two** forces, the one not touching it.

iv. ✓ **True**

v. ✗ **False**: Like (same direction) forces have a resultant equal to their **sum**; it is unlike forces whose resultant is their difference.

vi. ✓ **True**

Each carries 0.5 mark.

3 Multiple choice

i. **b.** the angle between Q and R — K · 1

Each force goes with the angle between the other two, the one not touching it.

ii. **c.** 90° — U · 1

They form a 3–4–5 triangle, whose angle between the sides 3 and 4 is 90°; the angle between the forces is $180° - 90° = 90°$. Here the two angles happen to agree; in general they don't.

iii. **c.** 100 N — U · 1

$T = \dfrac{W}{2\cos\alpha} = \dfrac{100}{2 \times 0.5} = 100$ N. 50 N would be right only for vertical strings, sharing the weight.

iv. **b.** 0.5 m from the 30 N force — A · 1

$R = 40$ N, between them, with $30 \times a = 10 \times b$, $a + b = 2$: $a = 0.5$ m, nearer the larger force.

v. **c.** grows without limit — HA · 1

$P = W\tan\theta$, and $\tan\theta \to \infty$ as $\theta \to 90°$: a horizontal push can't hold a body against a nearly vertical smooth wall, since only friction (none here) could hold it up.

4 Short answers

a. MARKING SCHEME — U · 2

✓ $P = 28.9$ N.

✓ $R = 57.7$ N.

b. MARKING SCHEME — A · 2

✓ $P + Q = 60$ and $P \times 1 = Q \times 2$.

✓ 40 N at 1 m and 20 N at 2 m.

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c. **ANSWER** A · 5

The angles between the forces: between the two strings $30° + 45° = 75°$; between the $30°$ string and the weight $180° - 30° = 150°$; between the $45°$ string and the weight $180° - 45° = 135°$.

Lami: $\frac{T_1}{\sin 135°} = \frac{T_2}{\sin 150°} = \frac{80}{\sin 75°} = 82.82$.

$T_1 = 82.82 \times 0.7071 =$ **58.6 N** (the string at $30°$); $T_2 = 82.82 \times 0.5 =$ **41.4 N** (at $45°$).

Check: $58.56 \sin 30° = 29.28$ and $41.41 \sin 45° = 29.28$ ✓. The steeper string carries more.

MARKING SCHEME

- ✓ The three angles between the forces.
- ✓ Lami's theorem written with the right pairs.
- ✓ $T_1 = 58.6$ N.
- ✓ $T_2 = 41.4$ N.
- ✓ The horizontal parts checked equal.

5 Think

ANSWER HA · 3

Each half makes an angle α with the vertical, $\tan \alpha = \frac{2}{\text{sag}}$, and $T = \frac{W}{2 \cos \alpha}$.

Sag 0.5 m: $\tan \alpha = 4$, $\alpha = 76.0°$, $T = \frac{10}{2 \times 0.2425} =$ **20.6 N**. Sag 0.05 m: $\tan \alpha = 40$, $\alpha = 88.6°$, $T \approx$ **200 N**.

A straight line would have $\alpha = 90°$, $\cos \alpha = 0$: the strings would pull only sideways, with nothing upward to hold the 10 N, whatever the tension. As the line straightens, T grows without limit, and the line or its posts give first.

MARKING SCHEME

- ✓ $T = \frac{W}{2 \cos \alpha}$ with $\tan \alpha = \frac{2}{\text{sag}}$.
- ✓ About 20.6 N and 200 N.
- ✓ Straight means $\cos \alpha = 0$: no upward pull, so no tension is enough.

6 Activity: Weighing with two strings

(not marked)

WHAT STUDENTS SHOULD FIND

With the scale in string 1, the reading is close to $\frac{W \sin \beta}{\sin (\alpha + \beta)}$, within the error of reading the angles (a few degrees changes it by a few percent; a scale reading in kilograms gives newtons on multiplying by about 9.8). As the strings are pulled apart, both tensions rise fast: past about $60°$ each, each string pulls harder than the bottle weighs.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	4	7	8	4	**23**

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