The Iron Man suit: a science worksheet

Eight middle school science problems on the real machines behind the suit. Free from thesuit.cc, where you can take the suit apart in 3D.

Name _____ Class _____ Date _____

Use g = 10 N/kg (each kilogram weighs 10 newtons on Earth). Each problem names the real machine its numbers come from; the guides at thesuit.cc/engineering explain each one.

1. Mass and weight

A real armored suit would have a mass of about 200 kg (weight guide).

- (a) What is its weight on Earth, in newtons?
- (b) On the Moon, each kilogram weighs only 1.6 N. What would the suit weigh there?
- (c) Does the suit's mass change on the Moon? Explain.

2. How fast is a real jet suit?

The fastest flight in a real jet suit is 137 km/h, a world record set in 2019 (speed guide).

- (a) What is 137 km/h in metres per second? (Divide by 3.6.)
- (b) How many seconds would the jet suit take to fly 1 km at that speed?
- (c) A car on a highway drives at 110 km/h. Which is faster, and by how much?

3. Running out of fuel

The real jet suit burns about 4 litres of fuel every minute and carries 40 litres (flight guide).

- (a) How many minutes can it fly?
- (b) At 137 km/h, how far could it fly in that time?

4. Titanium or steel?

Titanium has a density of 4.4 g/cm³ and steel 7.9 g/cm³. A helmet shell uses 1,000 cm³ of metal (materials guide).

- (a) What would the helmet's mass be in titanium, and in steel, in kilograms?
- (b) Which metal would you choose for a suit that has to fly, and why?

5. Balanced forces in a hover

To hover, a suit's engines push up while gravity pulls down. The suit and its wearer weigh 3,000 N.

- (a) How much upward thrust do the engines need to hover?
- (b) What happens if the thrust is 3,500 N?
- (c) What happens if the thrust drops to 2,500 N?

6. Energy for a real exoskeleton

The Sarcos Guardian XO, a real powered exoskeleton, uses about 500 watts (exoskeleton guide).

- (a) How much energy does it use in 2 hours, in kilowatt-hours? (1 kWh = 1,000 W for 1 hour.)
- (b) A phone battery stores about 15 watt-hours. About how many phone batteries would it take to run the exoskeleton for 2 hours?

7. Body heat in a sealed suit

Your body gives off about 100 W of heat at rest and about 500 W when working hard. In a sealed suit, that heat has nowhere to go unless the suit removes it (cooling guide).

- (a) How many joules of heat does a hard-working wearer give off in 10 minutes? (1 W = 1 joule every second.)
- (b) Why does a sealed suit need a cooling system?

8. Stopping safely

A flying suit moving at 20 m/s stops in 1 second (life support guide).

- (a) What is its deceleration in m/s²? (Change in speed ÷ time.)
- (b) How many g is that? (Divide by 10.)
- (c) If it stopped from 100 m/s in half a second instead, how many g would the wearer feel? People pass out at about 5 g. Would the wearer be safe?

Answer key

1. Mass and weight

- (a) 200 kg × 10 N/kg = **2,000 N**
- (b) 200 kg × 1.6 N/kg = **320 N**
- (c) **No.** Mass is the amount of matter in the suit, which is the same everywhere; weight is the pull of gravity on it, which is weaker on the Moon.

2. How fast is a real jet suit?

- (a) 137 ÷ 3.6 = **38 m/s** (38.1)
- (b) 1,000 m ÷ 38.1 m/s = **26 seconds**
- (c) **The jet suit**, by 137 – 110 = **27 km/h**

3. Running out of fuel

- (a) 40 ÷ 4 = **10 minutes**
- (b) 10 minutes is 1/6 of an hour, so 137 ÷ 6 = **about 23 km**

4. Titanium or steel?

- (a) Titanium: 1,000 × 4.4 = 4,400 g = **4.4 kg**. Steel: 1,000 × 7.9 = 7,900 g = **7.9 kg**
- (b) **Titanium**: it is almost half the mass for the same size, and every kilogram has to be lifted by the engines.

5. Balanced forces in a hover

- (a) **3,000 N**, equal to the weight, so the forces balance.
- (b) There is 500 N more force up than down, so the suit **speeds up upward** (it climbs faster and faster).
- (c) There is 500 N more force down than up, so the suit **speeds up downward**: it starts to fall.

6. Energy for a real exoskeleton

- (a) 500 W × 2 h = 1,000 Wh = **1 kWh**
- (b) 1,000 Wh ÷ 15 Wh = **about 67 phone batteries**

7. Body heat in a sealed suit

- (a) 500 W × 600 s = **300,000 J** (300 kJ)
- (b) The heat would build up inside the suit and the wearer would overheat. Real spacesuits pump cool water through tubes in an undergarment to carry it away.

8. Stopping safely

- (a) 20 ÷ 1 = **20 m/s²**
- (b) 20 ÷ 10 = **2 g**, about what you feel on a fast roller coaster
- (c) 100 ÷ 0.5 = 200 m/s², which is **20 g**. **Not safe**: that is four times the 5 g at which people pass out.