Unit 11 · Force

HARDER PRACTICE QUESTIONS

Full marks 52

Write your answers on separate paper. Show your working. Use $g = 9.8\ m/s^2$, $\pi = 3.14$, $G = 6.67 \times 10^{-11}\ N\ m^2/kg^2$, and for the Earth $GM = 3.98 \times 10^{14}\ N\ m^2/kg$ and $R = 6{,}371\ km$.

1 Spot the mistakes [4]

Lakpa's pendulum has a thread 95.0 cm long and a bob 4.0 cm across. He timed 20 swings, each from one side to the other, and got 19.8 s. He wrote:
"$T = 19.8 \div 20 = 0.99$ s and $l = 0.95$ m, so $g = 4\pi^2 l/T^2 = 38\ m/s^2$."

i. Name his two mistakes.
ii. Work out g correctly.

2 A clock on a hot day [3]

A pendulum clock keeps perfect time in a cool room, with a period of 2.000 s. On a hot day its rod is 0.10% longer. How many seconds does the clock lose in a day? (A day is 86,400 s.)

3 Which reading is wrong? [5]

Pasang timed 20 oscillations of a pendulum at four lengths.

l (m)	0.40	0.60	0.80	1.00
Time for 20 oscillations (s)	25.4	34.4	35.9	40.1

i. Copy the table and add rows for T and T^2.
ii. One reading is out of line with the others. Which, and how can you tell?
iii. From the other three, find the slope of T^2 against l, and from it g.
iv. What should the wrong time have been?

4 Half the grip [4]

A bus of mass 12,000 kg goes round a bend of radius 50 m. On a dry road its tyres can give at most 60,000 N towards the center of the bend, and on a wet road at most 30,000 N.

i. Find the greatest safe speed on each road, in km/h.
ii. Milan says: "The grip is halved, so the driver only has to halve his speed." Is this enough, or more than he needs? Explain.

5 Is the ride possible? [4]

A giant wheel at a mela has a radius of 10 m. A rider at the very top would feel weightless if the centripetal acceleration there were equal to g.

i. Find the speed at which this happens, and the time for one round at that speed.
ii. The wheel really turns once in 40 s. Find the rider's centripetal acceleration, and say what fraction of g it is.

6 Find a height from a day [5]

A geostationary satellite goes round the Earth once in 24 hours. The Earth's gravity is the centripetal force on it.

i. Starting from $mv^2/r = GMm/r^2$ and $v = 2\pi r/T$, show that $r^3 = GMT^2/(4\pi^2)$.
ii. Find r, and the satellite's height above the surface.
iii. Does the satellite's mass matter? How can you tell?

7 Too fast and too slow [5]

Take the potential at the Earth's surface as -6.25×10^7 J/kg, and ignore the air.

i. A probe is fired from the surface at 15 km/s. How fast is it going when it is very far away?
ii. Another is fired straight up at 5.0 km/s. Use energy to find how far from the Earth's center it stops, and so its greatest height.
iii. Using mgh with g = 9.8 m/s^2, Aakriti gets 1,276 km for the same throw. Why is her answer too small?

8 Predict, then explain [3]

Write your prediction first, then explain it.

A planet has half the Earth's mass and half its radius. Predict whether each of these is bigger than, smaller than or the same as on the Earth: (a) the field intensity at the surface; (b) the escape velocity; (c) the period of a 1 m pendulum there.

9 Pass or fail? [5]

An empty single-decker bus of mass 10,000 kg has its CG 1.2 m above the road and its wheels 2.0 m apart. Roof luggage is carried with its own CG 3.0 m above the road. In Hong Kong a single-decker must tilt to 35° without tipping over. Treat the bus as rigid, and take tan 35° = 0.70.

i. Find the height of the CG with 1,500 kg on the roof.
ii. At what angle does it now tip? Does it pass the 35° test?
iii. What is the greatest load on the roof with which it passes?

10 Work backwards [2]

A uniform meter stick with a 50 g mass hung at its 10 cm mark balances on a knife edge at its 40 cm mark. Find the mass of the stick.

11 Design a measurement [4]

Suraksha wants to check whether a pendulum with a period of about 2 s really takes 1.7% longer at 30° than at a small angle, as the unit says. Her thumb on the stopwatch makes an error of about 0.2 s.

i. Show that timing one oscillation would be no use, and that timing 20 could show the difference.
ii. Name what she changes and two things she keeps the same.
iii. What might go wrong in timing many swings at 30°, and how could she allow for it?

12 Correct the misconceptions [3]

The paragraph has three mistakes. Write each one and correct it.

Reshma wrote: "When mud leaves a bicycle's tyre, the centrifugal force throws it straight outwards along the radius. This force is the reaction to the centripetal force on the mud. Mud near the hub moves just as fast as mud at the rim, because all points of a wheel turn in the same time."

13 Think [3]

Between the Earth and the Moon, about 346,000 km from the Earth's center and 38,400 km from the Moon's, the two fields cancel. Santosh says: "The field is zero there, so the potential must be zero too, and a rocket there has escaped from the Earth." Is he right? Take the Moon's GM as 4.90 $\times 10^{12}$ N m^2/kg, and find the potential there.

14 Make your own [2]

Invent a planet on which a pendulum of effective length 1.0 m has a period of exactly 4.0 s. Find the g it needs, then give it a radius of your choice and find its mass.