S5 Physics Practice Paper: Newton's Laws and Friction, Momentum and Collisions, Circular Motion and Gravitation, Work and Energy Conservation, Wave Speed and Wave Properties, Refraction, Total Internal Reflection and Lenses (100 marks)

Level: S5 | Subject: Physics | 75 minutes | 100 marks | 24 questions | answer key

Section A: Newton's Laws and Friction (17 marks)

Each question is worth 4-5 marks; show the formula used and the substitution.

#	Question	Answer	Marks
1	A car of mass 1,200 kg starts from rest on a level road under a net force of 4,800 N. Find (a) the acceleration, (b) the speed after 5.0 s, (c) the distance travelled in the first 5.0 s.	(a) a = F/m = 4,800 / 1,200 = 4.0 m/s2; (b) v = at = 4.0 x 5.0 = 20 m/s; (c) s = 0.5 x 4.0 x 25 = 50 m.	4
2	A 5.0 kg block rests on a horizontal table; the coefficient of kinetic friction is 0.30. A horizontal push of 30 N is applied (g = 9.81 m/s2). Find (a) the friction, (b) the acceleration of the block.	(a) f = 0.30 x 5.0 x 9.81 = 14.715 ~ 14.7 N; (b) net force = 30 - 14.715 = 15.285 N, a = 15.285 / 5.0 = 3.057 ~ 3.1 m/s2.	4
3	In the set-up shown, a 12 kg block on a horizontal table (kinetic friction 0.20) is joined by a light string over a smooth pulley to an 8.0 kg hanging mass. Find (a) the acceleration of the system, (b) the tension (g = 9.81 m/s2).	(a) a = (8.0 - 0.20 x 12) x 9.81 / 20 = 5.4 x 9.81 / 20 = 2.7468 ~ 2.75 m/s2; (b) T = 8.0 x (9.81 - 2.7468) = 56.5056 ~ 56.5 N.	5
4	A 70 kg person stands on a scale inside a lift. Find the reading when (a) the lift accelerates upwards at 2.0 m/s2, (b) the lift moves upwards at constant speed (g = 9.81 m/s2).	(a) R = 70 x (9.81 + 2.0) = 826.7 N; (b) a = 0, R = 70 x 9.81 = 686.7 N.	4

Section B: Momentum and Collisions (17 marks)

Each question is worth 4-5 marks; take rightwards as positive; use kg m/s for momentum.

#	Question	Answer	Marks
5	A 0.45 kg ball hits a wall normally at 8.0 m/s and rebounds at 6.0 m/s. The contact time is 0.050 s. Find (a) the change in momentum, (b) the average force on the ball.	(a) change in momentum = 0.45 x 14.0 = 6.3 kg m/s away from the wall; (b) F = 6.3 / 0.050 = 126 N.	4
6	A 3.0 kg trolley moving at 4.0 m/s collides with a stationary 2.0 kg trolley and they stick together. Find (a) the common speed, (b) the kinetic energy lost.	(a) 12 = 5.0v so v = 2.4 m/s; (b) KE before = 24 J, KE after = 0.5 x 5.0 x 5.76 = 14.4 J, lost 9.6 J.	5
7	A 2.0 kg ball moving at 6.0 m/s makes a head-on elastic collision with a stationary 4.0 kg ball. Find their velocities after the collision.	v1 = (2.0 - 4.0)/6.0 x 6.0 = -2.0 m/s (rebounds); v2 = 4.0/6.0 x 6.0 = 4.0 m/s. Check momentum: 2.0 x (-2.0) + 4.0 x 4.0 = 12 = initial momentum.	4
8	A 4.0 kg rifle fires a 0.020 kg bullet horizontally at 400 m/s. Find (a) the momentum of the bullet, (b) the recoil speed of the rifle.	(a) p = 0.020 x 400 = 8.0 kg m/s; (b) 4.0 v = -8.0 so v = -2.0 m/s, recoil speed 2.0 m/s.	4

Section C: Circular Motion and Gravitation (17 marks)

Each question is worth 4-5 marks; give answers to a sensible number of significant figures.

#	Question	Answer	Marks
9	A car takes a flat bend of radius 50 m at 20 m/s. Find (a) the centripetal acceleration, (b) the minimum coefficient of friction needed (g = 9.81 m/s2).	(a) a = 400 / 50 = 8.0 m/s2; (b) mu = a/g = 8.0 / 9.81 = 0.8155 ~ 0.82.	4
10	A satellite orbits the Earth in a circle of radius 7.0 x 10^6 m from the Earth centre (mass 5.97 x 10^24 kg, G = 6.674 x 10^-11). Find (a) the orbital speed, (b) the period in minutes.	GM = 3.984 x 10^14; (a) v = sqrt(3.984e14 / 7.0e6) = sqrt(5.69e7) ~ 7.54 x 10^3 m/s; (b) T = 2 pi r / v ~ 5.83 x 10^3 s ~ 97 minutes.	5
11	A 0.50 kg ball on a 0.80 m string moves in a horizontal circle at 120 revolutions per minute. Find (a) the angular speed, (b) the linear speed, (c) the centripetal acceleration.	(a) omega = 2 pi x 120 / 60 = 12.566 ~ 12.6 rad/s; (b) v = 12.566 x 0.80 ~ 10.05 m/s; (c) a = 12.566^2 x 0.80 ~ 126 m/s2.	4
12	The gravitational field strength on a planet surface is 9.81 m/s2. A second planet has the same mass but twice the radius. Find (a) its surface field strength, (b) the weight of a 60 kg person there.	(a) g is proportional to 1/r^2, so g = 9.81 / 4 = 2.4525 ~ 2.45 m/s2; (b) W = 60 x 2.4525 = 147.15 ~ 147 N.	4

Section D: Work, Energy and Power (17 marks)

Each question is worth 4-5 marks; state the energy conservation you use.

#	Question	Answer	Marks
13	A force of 120 N is applied to a crate at 30 degrees above the horizontal and the crate moves 8.0 m along the floor. Find the work done by the force.	W = F d cos(theta) = 120 x 8.0 x 0.8660 = 831.4 ~ 831 J.	4
14	A 400 kg roller-coaster car descends from rest at a height of 25 m to a height of 5.0 m, friction being negligible. Find (a) its speed at the lower point, (b) its kinetic energy there (g = 9.81 m/s2).	Drop = 20 m; (a) v = sqrt(2 x 9.81 x 20) = sqrt(392.4) = 19.81 ~ 19.8 m/s; (b) KE = 0.5 x 400 x 392.4 = 78,480 ~ 7.8 x 10^4 J.	5
15	A pump raises 1,200 kg of water through 15 m every minute. If the efficiency is 0.75, find (a) the useful output power, (b) the input power (g = 9.81 m/s2).	(a) P = 1,200 x 9.81 x 15 / 60 = 2,943 W ~ 2.9 kW; (b) input = 2,943 / 0.75 = 3,924 W ~ 3.9 kW.	4
16	A spring of stiffness 800 N/m is compressed by 0.15 m and released to push a 0.50 kg ball, friction being negligible. Find (a) the energy stored, (b) the speed of the ball leaving the spring.	(a) E = 0.5 x 800 x 0.0225 = 9.0 J; (b) v = sqrt(2 x 9.0 / 0.50) = sqrt(36) = 6.0 m/s.	4

Section E: Wave Properties (16 marks)

Each question is worth 4 marks; write down the formula used.

#	Question	Answer	Marks
17	A wave has frequency 250 Hz and wavelength 1.36 m. Find its speed.	v = f x lambda = 250 x 1.36 = 340 m/s, the speed of sound in air.	4

18	A string of length 0.80 m is fixed at both ends, under a tension of 120 N, with linear density 0.030 kg/m. Find (a) the wave speed on the string, (b) the fundamental frequency.	(a) v = sqrt(120 / 0.030) = sqrt(4000) ~ 63.25 m/s; (b) f1 = 63.25 / 1.60 ~ 39.5 Hz.	4
19	In a ripple-tank experiment, 12 wave crests pass a fixed point in 3.0 s and adjacent crests are 0.06 m apart. Find (a) the frequency, (b) the period, (c) the wave speed.	(a) f = 12 / 3.0 = 4.0 Hz; (b) T = 0.25 s; (c) v = 4.0 x 0.06 = 0.24 m/s.	4
20	(a) Thunder is heard 3.5 s after lightning is seen; find the distance to the strike (speed of sound 340 m/s). (b) Ultrasound of frequency 2.0 MHz has a wavelength of 0.77 mm in tissue; find its speed.	(a) d = 340 x 3.5 = 1,190 ~ 1.2 x 10^3 m; (b) v = 2.0e6 x 0.77e-3 = 1,540 m/s.	4

Section F: Refraction, Total Internal Reflection and Lenses (16 marks)

Each question is worth 4 marks; give angles in degrees to one decimal place.

#	Question	Answer	Marks
21	A ray of light travels from air into glass of refractive index 1.50 at an angle of incidence of 40 degrees. Find the angle of refraction.	sin r = sin 40 / 1.50 = 0.6428 / 1.50 = 0.4285, so r = 25.37 ~ 25.4 degrees.	4
22	Find the critical angle for light travelling from glass of refractive index 1.50 into air, and state what happens when the angle of incidence exceeds it.	sin c = 1/1.50 = 0.6667 giving c = 41.81 ~ 41.8 degrees; beyond it total internal reflection occurs and no light is refracted out.	4
23	A convex lens of focal length 12 cm has an object 18 cm in front of it. Find (a) the image distance, (b) the magnification, (c) the nature of the image.	(a) 1/v = 1/12 - 1/18 = 1/36 so v = 36 cm behind the lens; (b) m = 36/18 = 2.0; (c) real, inverted and magnified.	4
24	A concave lens of focal length 15 cm has an object 30 cm in front of it. Find (a) the image distance, (b) the magnification, (c) the nature of the image.	(a) f = -15 cm, 1/v = -1/15 - 1/30 = -0.10 so v = -10 cm, a virtual image on the same side; (b) m = -10/30 = -0.33; (c) upright, diminished and virtual.	4