est hardship. According to UNICEF, 50% of children under five are malnourished and 40% of female children do not attend school. The government's annual per capita investment in health and education is approximately $14 compared to, for example, $160 in South Korea. There are about 328 million people in India who fall below the poverty line, that is with income of less than $25 per month.

The United Nations' Human Development Index ranks India 135th of the 174 countries listed, well below Kenya, Ghana, Equatorial Guinea and just above Nigeria, Zambia, and the Republic of the Congo (Zaire).

India has the fourth-largest foreign debt among sovereign nations ($93.2 billion), with 9% inflation of consumer prices. India's per capita GDP is $340. The government spends $420 million each year to promote family planning, according to Secretary of Health and Family Welfare Y.N. Chaturvedi.

A large percentage of the population is highly educated and vocationally trained. There are 2 million engineers and scientists and approximately 50 million people with a secondary education. Universities are graduating more than the system can absorb and support. The remaining population has very little education. India is projected to have the largest population of illiterates in the world by 2000.

Reforms in 1991 and 1993 have set a new direction for the country's formerly closed economy, which had been marked by complacency. In the past few years, the economy has been improving with imports and exports up, finally enabling India to join the world economy.

India's 40 million most affluent can purchase cars either with cash or through financing. About 500,000 citizens are very wealthy by western standards. By 2000, an expanding segment of the population (forecast to reach 60 million) will be able to afford a new or used car. Most of the increases will come from those who currently drive motorcycles, scooters, and mopeds.

India's vehicle market will become very competitive at a very fast pace. Vehicle production will place a strain on component suppliers with manufacturing plants in remote areas of the country. At issue will be the transport infrastructure for on-time deliveries.

Raymond Champagne
Interesting? Circle 159
Not interesting? Circle 160

Toyota Prius

Toyota has christened its gasoline-electric hybrid car Prius, taking the name from the company's 1995 Tokyo Motor Show concept car. The Prius is said to be Japan's first, and one of the world's first, series production internal-combustion engine/electric motor-driven passenger cars. Prius, according to Toyota, means "pioneering" in Latin. The compact four-seat sedan is priced at 2.15 million yen, about $20,000, "Two One" signifying the coming century.

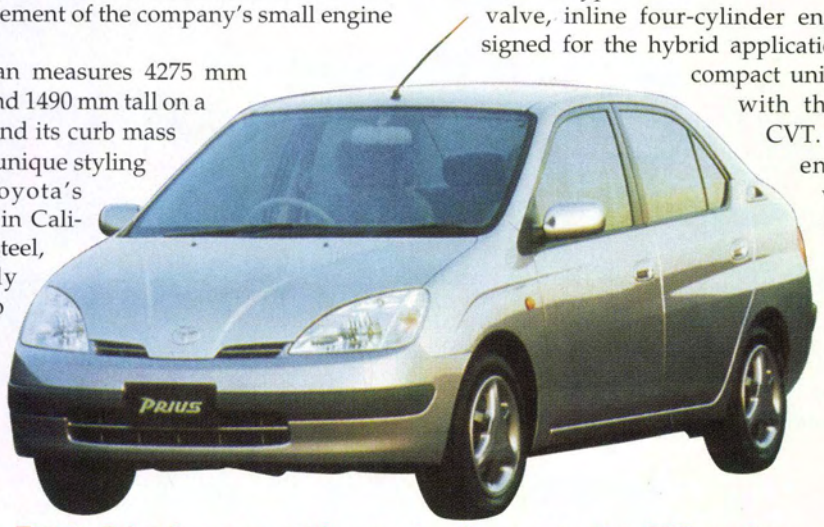
The Prius is on a new platform, exclusive to the hybrid car at this time, though it will serve in other small cars. Likewise, the type 1NZ-FXE engine shares its basic architecture with the forthcoming replacement of the company's small engine family, the 4E series.

The four-door sedan measures 4275 mm long, 1695 mm wide, and 1490 mm tall on a 2550-mm wheelbase, and its curb mass is 1515 kg. The Prius' unique styling is a creation of Toyota's CALTY design center in California. The car's all-steel, welded integral body shell was designed to Toyota's GOA (global outstanding assessment) standards, and meets the world's toughest crash requirements, including Japan's frontal and side impacts at 50 km/h and Europe's forthcoming frontal 40% offset impact at 56 km/h. Toyota subjected the Prius to its own draconian crash tests, including a frontal 40% offset crash at 60 km/h, in which the car is said to have performed extremely well.

The Prius employs a parallel hybrid system, using both the internal combustion engine and electric motor for propulsion. Toyota, by the way, preceded the Prius with a series hybrid vehicle, an electrically driven mini bus whose gasoline engine is used to generate electricity and recharge the battery.

The type 1NZ-FXE dual-overhead-camshaft, 16-valve, inline four-cylinder engine was purpose-designed for the hybrid application. It is an extremely compact unit, to be installed inline with the electric motor and CVT. The aluminum 1.5-L engine, placed transversely, measures 560 mm long, 595 mm wide, and 680 mm tall, with a mass of 88.3 kg inclusive of coolant, lubricant, and air cleaner.

Both the cylinder head and block are die-cast in aluminum, the latter with thin (2.0 mm) iron liners. The engine has a 75 mm bore to a long 84.7 mm



Toyota Prius is a compact four-seat sedan, measuring 4275 mm long, 1695 mm wide, and 1490 mm tall on a 2500-mm wheelbase.

stroke with a tight bore pitch of 83 mm, and a total displacement of 1496 cm^3. An interesting feature is the adoption of an offset crankshaft, whose journal center is 12 mm off the bore center, to minimize the piston's side-thrust, for the sake of optimum efficiency. The forged crankshaft is fitted with four balance weights, attaining a 70% balancing ratio, and is supported by five main bearings whose size is 46 mm in diameter and 22 mm in width. The pin diameter is 34 mm and width 18 mm.

A single-row, 8.0-mm-pitch roller chain drives dual overhead camshafts, a rare practice for Toyota, which seems to favor timing belts. Again this method is used for compact packaging. The camshaft acts on valves via inverted bucket tappets with inner clearance shims. The engine adopts VVT-i, continuously variable intake valve timing ("i" is for intelligent, signifying electronic control, which alters the intake valve timing for a maximum value of 40° of crankshaft revolution). Valve timings are as follows:

Intake valve opens* (deg)	30	ATDC/10 BTDC
closes (deg)	120	ABDC/80 ABDC
Exhaust valve opens (deg)	32	BBDC
closes (deg)	2	ATDC

* continuously variable valve timing

The VVT-i improves low- and mid-speed torque and fuel economy, and reduces exhaust emissions and minimizes powertrain vibrations during engine start-up (the vehicle normally moves off on electric power, and the engine comes in when accelerating).

The engine operates in the Atkinson/Miller-cycle, employing late intake valve closing, thereby obtaining a higher charge expansion ratio without resorting to an extraordinarily high virtual compression ratio, and reducing pumping loss. The combustion chamber shape conforms to Toyota's recent favorite, the angled squish area design. Valve diameters are 30.5 mm for intake and 25.5 mm for exhaust.

The 1NZ-FXE produces 42.7 kW JIS net at 4000 rpm and a maximum torque of 102 N•m at 4000 rpm on a 13.5:1 compression ratio, and is content with unleaded, regular grade gasoline. The engine operates in a relatively narrow and optimally efficient band.

The electric motor/regenerator is a permanent magnet, synchronous, ac, watercooled type rated at 30 kW at 940-2000 rpm and 305 N•m peak torque produced at 0-940 rpm. The parallel hybrid system employs a separate generator, which supplies power to the propulsion motor that recharges the battery, and by modulating the amount of electricity generated, controls the planetary-gear-type transaxle's continuously variable transmission function. Both the motor/regenerator and the generator are of Toyota's own design and manufacture.

The transaxle is essentially an electrically controlled CVT, by a clever use of a planetary geartrain, whose sun gear is connected to the generator, the planetary gear-carrier to the engine, and the ring gear to the motor/output shaft. It splits driving torque between the engine and motor, and also functions as a continuously variable transmission.

The parallel Toyota Hybrid System (THS) operates as follows:

System start: the engine is started. It automatically stops when coolant temperature reaches a preset level:

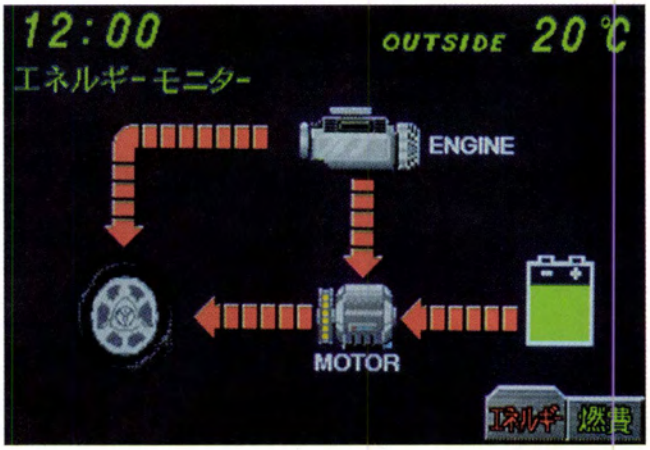
Low-speed operation: where the engine's efficiency is low, it is stopped by fuel cutoff, and the vehicle is propelled by the electric motor. The battery supplies electricity.

Normal operation: the engine's output is split to 1) drive the wheels via a torque-split system (CVT), and 2) drive the generator whose electricity is supplied via invertor to the motor which adds to vehicle propulsion

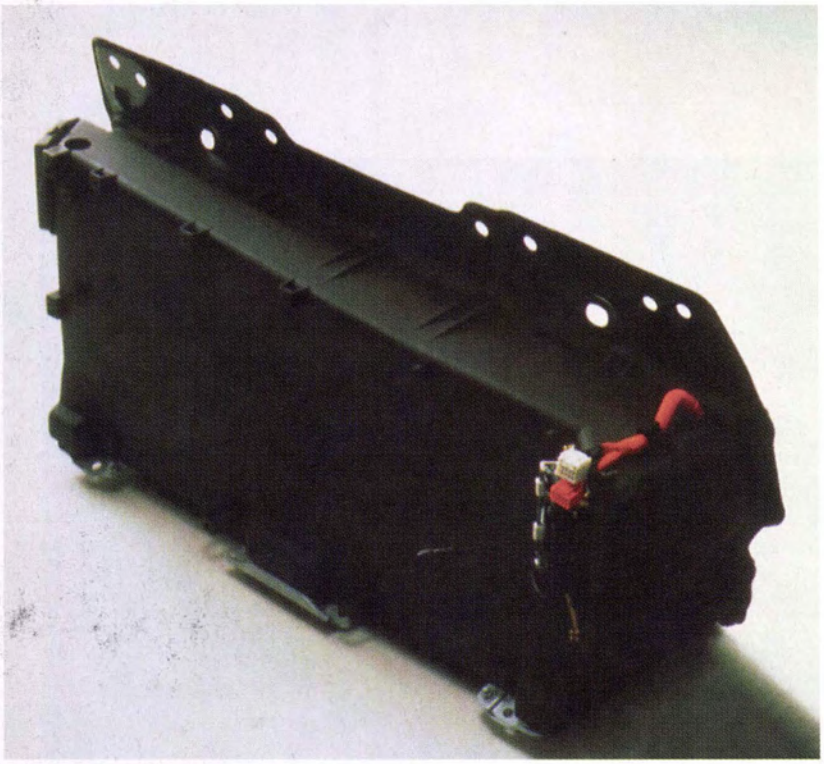
High-load operation: as in full acceleration, the battery's electricity is added to the motor for increased torque output

Deceleration: the motor is employed to regenerate electricity which is stored in the battery.

Instrumentation is digital, in the center top of the instrument panel, below which is a multipurpose display.



Display shows both the engine and electric motor driving the vehicle, with both the battery and generator feeding electricity to the motor. Another display shows fuel consumption and energy regeneration every five minutes, in 50 W•h units.



Prius' high-output nickel-hydride battery pack (top) is positioned between the rear seat and luggage compartment. Below is the inverter unit, whose electronic elements are of Toyota's own design and manufacture, as is the motor regenerator.

The battery's charge level is monitored and maintained by bringing in the engine to recharge it. Further, the engine is called upon to drive the generator to recharge the battery, to drive the air conditioning compressor, and to raise coolant temperature to the operating level.

The battery pack is a high-output nickel-hydride type, comprising 240 cells of 12 V each, obtaining a total voltage of 2880 V. A senior engineer sees a very long life with this battery type, not witnessing a single instance of failure during his team's long endurance test programs.

The chassis employs front MacPherson strut suspension, and a variation of a twist-beam design at the rear. The latter is fitted with a triple-rubber-bushed toe-control link at each mount pivot to the body. A conventional twist-beam axle tends to assume a toe-out attitude when subjected to lateral force as in cornering or lane-change because of the attaching pivot bushings' elasticity. The toe-control links enable true lateral displacement of the axle, thereby assuring stability.

Steering is by rack and pinion, and is electronically controlled and electrically assisted with an electric motor acting on the pinion shaft.

Front ventilated disc and rear drum brakes are combined with ABS and hydraulic servo assistance. The THS's regenerative braking effect is also incorporated in the total brake system. The Prius is fitted with 165/65R15 tires on lightweight, cast aluminum wheels.

The front seat belt system includes a pyrotechnically activated pretensioner and force limiter. Dual SRS air bags are standard.

The Prius' instrumentation is located at the top center of the instrument panel, and is a digital/graphic display. Additionally there is an LCD-color energy monitor in the central console, which shows the instantaneous flow of energy within THS (which of the propulsion units is/are driving, is the battery being depleted or filled). The display may also show fuel/energy consumption/regeneration in 30 minutes at five-minute increments. An optional navigation/information system also uses this display.

Toyota claims a Japanese 10/15-mode fuel consumption of 28 km/L, about 66 mpg, which halves consumption of a typical small gasoline engine car of comparable performance and size.

Jack Yamaguchi

Interesting? Circle 161
Not interesting? Circle 162