HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY
ADVANCED PROGRAMS - PHYSICS HOMEWORK

1. MECHANICS

1.4 ENERGY AND CONSERVATIVE FORCE

Name:.. Date of birth:..

Class:.. Student ID:..

Grade table

Question:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Points:	4	5	6	5	5	6	3	5	4	6	6	3
Score:												

Question:	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	Total
Points:	9	3	6	4	10	5	8	5	5	8	5	126
Score:												

1. How much work did the movers do (horizontally) pushing a 46.0-kg crate 10.3 m across a rough floor without acceleration, if the effective coefficient of friction was 0.50? [4]

....

....

....

....

....

....

....

....

2. In a certain library the first shelf is 15.0 cm off the ground, and the remaining four shelves are each spaced 38.0 cm above the previous one. If the average book has a mass of 1.40 kg with a height of 22.0 cm, and an average shelf holds 28 books (standing vertically), how much work is required to fill all the shelves, assuming the books are all laying flat on the floor to start? [5]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

3. A grocery cart with mass of 16 kg is being pushed at constant speed up a 12° ramp by a force F_{P} which acts at an angle of 17° below the horizontal. The friction between the cart and the ramp is negligible. If the ramp is 7.5 m long, find the work done by **6 p**

(**a**) the weight $m\vec{\mathbf{g}}$, [3]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(**b**) the normal force $\vec{\mathbf{F}}_{\mathrm{N}}$, [1]

. . . .

. . . .

(**c**) the pushing force $\vec{\mathbf{F}}_{\mathrm{P}}$. [2]

. . . .

. . . .

. . . .

. . . .

4. A 17,000-kg jet takes off from an aircraft carrier via a catapult (**Fig. 4.1**). The gases thrust out from the jet's engines exert a constant force of 130 kN on the jet; the force exerted on the jet by the catapult is plotted in **Fig. 4.2**. **5 p**

Fig. 4.1

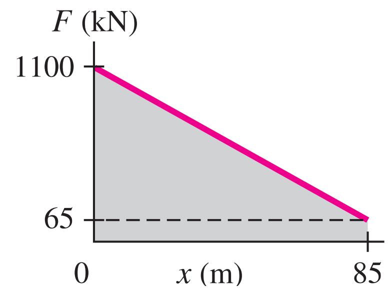

Fig. 4.2

Determine the work done on the jet:

(**a**) by the gases expelled by its engines during launch of the jet, [2]

. . . .

. . . .

. . . .

. . . .

(**b**) by the catapult during launch of the jet. [3]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

5. If the speed of a car is increased by 50%, by what factor will its minimum braking distance be increased, assuming all else is the same? Ignore the driver's reaction time. [5]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

6. One car has twice the mass of a second car, but only half as much kinetic energy. [6]

When both cars increase their speed by $8.0\,\mathrm{m\,s^{-1}}$, they then have the same kinetic energy.

What were the original speeds of the two cars?

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

7. If it requires 6.0 J of work to stretch a particular spring by 2.0 cm from its equilibrium length, how much more work will be required to stretch it an additional 4.0 cm? [3]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

8. A 66.5-kg hiker starts at an elevation of 1270 m and climbs to the top of a peak 2660 m high. **5 p**

(**a**) What is the hiker's change in potential energy? [2]

. . . .

. . . .

. . . .

. . . .

(**b**) What is the minimum work required of the hiker? [1]

. . . .

. . . .

(**c**) Can the actual work done be greater than this? Explain. [2]

. . . .

. . . .

. . . .

. . . .

9. A spring with $k = 83\,\mathrm{N\,m^{-1}}$ hangs vertically next to a ruler. The top end of the spring is next to the zero mark and the bottom end is next to the 15-cm mark on the ruler. [4]

If a 2.5-kg mass is now attached to the end of the spring, and the mass is allowed to fall, where will the end of the spring line up with the ruler marks when the mass is at its lowest position?

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

10. An engineer is designing a spring to be placed at the bottom of an elevator shaft. [6]

Suppose that the total mass of the elevator and passengers is m.

If the elevator cable breaks when the elevator is at a height h above the top of the spring, calculate the value that the spring constant k should have so that passengers undergo an acceleration of no more than $5.0g$ (g is the free fall acceleration) when brought to rest.

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

11. You drop a ball from a height of $2.0\,\mathrm{m}$, and it bounces back to a height of $1.6\,\mathrm{m}$. **6 p**

Air resistance is negligible.

(**a**) What fraction of the ball's initial energy is lost during the bounce? [3]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(**b**) Where did the energy go? What is the reason? [3]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

12. A projectile is fired at an upward angle of 38.0° from the top of a 135-m-high cliff with a speed of $165\,\mathrm{m\,s^{-1}}$. What will be its speed when it strikes the ground below? Air resistance is negligible. [3]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

13. Early test flights for the space shuttle used a "glider" (mass of 980 kg including pilot). **9 p**

After a horizontal launch at $480\,\mathrm{km\,h^{-1}}$ at a height of 3500 m, the glider eventually landed at a speed of $210\,\mathrm{km\,h^{-1}}$.

(**a**) What would its landing speed have been in the absence of air resistance? [4]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(**b**) What was the average force of air resistance exerted on it if it came in at a constant glide angle of 12° to the Earth's surface? [5]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

14. A 975-kg sports car accelerates from rest to $95\,\mathrm{km\,h^{-1}}$ in 6.4 s. What is the average power delivered by the engine, in W and in hp? ($1\,\mathrm{hp} = 0.7457\,\mathrm{kW}$). Neglect friction and air resistance. [3]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

15. A bicyclist coasts down a $6.0°$ hill at a steady speed of $4.0\,\mathrm{m\,s^{-1}}$. [6]

Assuming a total mass of $75\,\mathrm{kg}$ (bicycle plus rider), what must be the cyclist's power output to climb the same hill at the same speed?

....

....

....

....

....

....

....

....

....

....

....

....

16. A tennis ball of mass $m = 0.060\,\mathrm{kg}$ and speed $v = 28\,\mathrm{m\,s^{-1}}$ strikes a wall at a $45°$ angle and rebounds with the same speed at $45°$, as shown in **Fig. 16.1**. [4]

What is the impulse (magnitude and direction) given to the ball?

....

....

....

....

....

....

....

....

....

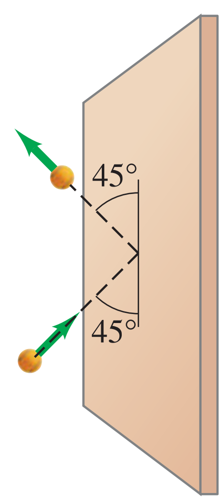

Fig. 16.1

17. **10 p**

(**a**) State Newton's law of gravitation. [2]

. . . .

. . . .

. . . .

. . . .

(**b**) The planet Jupiter and one of its moons, Io, may be considered to be uniform spheres that are isolated in space. [4]

Jupiter has radius R and mean density ρ. Io has mass m and is in a circular orbit about Jupiter with radius nR, as illustrated in **Fig. 17.1**.

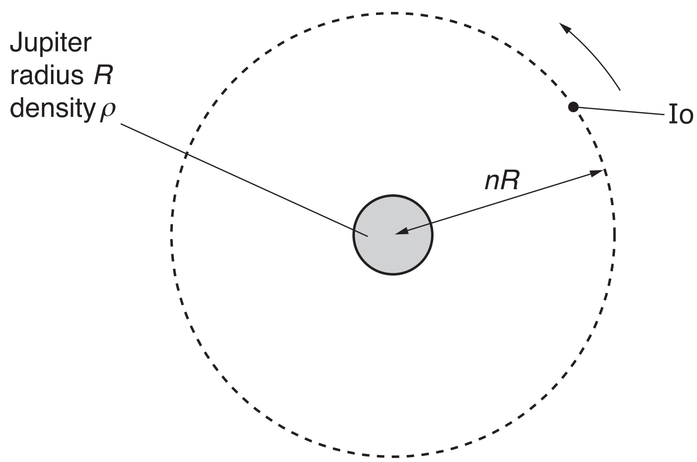

Fig. 17.1

The time for Io to complete one orbit of Jupiter is T. Show that the time T is related to the mean density ρ of Jupiter by the expression

$$\rho T^2 = \frac{3\pi n^3}{G}$$

where G is the gravitational constant.

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(**c**) **i**. The radius R of Jupiter is 7.15×10^4 km and the distance between the centers of Jupiter and Io is 4.32×10^5 km. The period T of the orbit of Io is 42.5 hours. [3]

Calculate the mean density ρ of Jupiter.

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

ii. The Earth is said to be a planet made of rock of mean density $5.5 \times 10^3\,\mathrm{kg\,m^{-3}}$. [1]

By reference to your answer in (**c**)-**i**., comment on the possible composition of Jupiter.

. . . .

. . . .

18. Rain is falling at the rate of $2.5\,\mathrm{cm\,h^{-1}}$ and accumulates in a pan. If the raindrops hit at $8.0\,\mathrm{m\,s^{-1}}$, estimate the force on the bottom of a $1.0\text{-}\mathrm{m^2}$ pan due to the impacting rain which we assume does not rebound. The density of water is $1.00 \times 10^3\,\mathrm{kg\,m^{-3}}$. [5]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

19. **8 p**

(**a**) Define *gravitational field strength*. [1]

. . . .

. . . .

(**b**) Explain why, for changes in vertical position of a point mass near the Earth's surface, the gravitational field strength may be considered to be constant. [2]

. . . .

. . . .

. . . .

. . . .

(**c**) The orbit of the Earth about the Sun is approximately circular with a radius of 1.5×10^8 km. The time period of the orbit is 365 days. [5]

Determine a value for the mass M of the Sun. Explain your working.

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

20. A ball of mass 0.440 kg moving east ($+x$ direction) with a speed of $3.80\,\mathrm{m\,s^{-1}}$ collides head-on with a 0.220-kg ball at rest. If the collision is perfectly elastic, what will be the speed and direction of each ball after the collision? [5]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

21. Suppose the force acting on a tennis ball (mass 0.060 kg) points in the $+x$ direction and is given by the graph of **Fig. 21.1** as a function of time. **5 p**

(**a**) Use graphical methods (count squares) to estimate the total impulse given to the ball. [3]

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

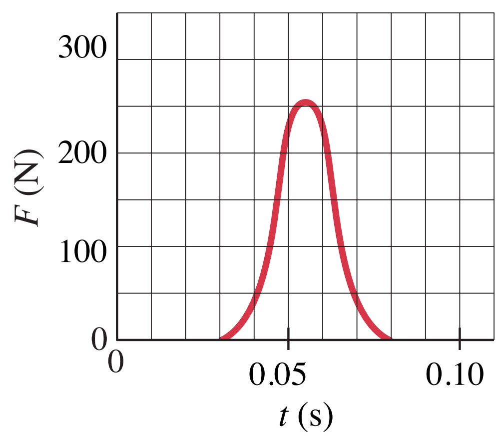

Fig. 21.1

(**b**) Estimate the velocity of the ball after being struck, assuming the ball is being served so it is nearly at rest initially. [2]

. . . .

. . . .

. . . .

. . . .

22. Determine the fraction of kinetic energy lost by a neutron ($m = 1.01\,\mathrm{u}$) when it collides head-on and elastically with a target particle at rest which is **8 p**

(**a**) ${}^{1}_{1}\mathrm{H}$ ($m = 1.01\,\mathrm{u}$), [5]

....

....

....

....

....

....

....

....

....

....

(**b**) ${}^{2}_{1}\mathrm{H}$ (heavy hydrogen, $m = 2.01\,\mathrm{u}$), [1]

....

....

....

(**c**) ${}^{12}_{6}\mathrm{C}$ ($m = 12.0\,\mathrm{u}$), [1]

....

....

....

(**d**) ${}^{208}_{82}\mathrm{Pb}$ ($m = 208\,\mathrm{u}$). [1]

....

....

....

23. An internal explosion breaks an object, initially at rest, into two pieces, one of which has 1.5 times the mass of the other. [5]

If 5500 J is released in the explosion, how much kinetic energy does each piece acquire?

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .