EXERCISES NO: 4

1. A worker lifts up a stone of 3.5kg to a height of 1.80m each 30s. Find the work done in one hour.

2. Calculate the kinetic energy and the velocity required for a 70kg pole vaulter to pass over a 5.0m high bar. Assume the vaulter's centre of mass is initially 0.90m off the ground and reaches its maximum height at the level of the bar itself.

3. Calculate the power required of a 1400kg car under the following circumstances

a) The car climbs a 10° hill at a steady 80km/h and

b) The car accelerates from 90 to 110km/h in 6.0s to pass another car on a level road. Assume the force of friction on the car is 700N in both parts of the problem.

4. A bullet is thrown obliquely in gravitational field, where g = 9.8 m/s^2 with a speed of 20m/s. Calculate its speed when it reaches the height of 10m.

5. A woman of mass 75kg walks up a mountain of height 20m.

a) What is the work done? b) The walking up being done in 1.5 min, find the power,

c) What time will be taken by this woman to walk up the 20m in order to develop a power of 73W?

6. A stone of 2000kg falls from the top of a tower of height H = 200m.

What is the total mechanical energy? What is the P.E at height h =H/2 and its K.E?

7. Using the K.E. theorem, find the acceleration of the following system:

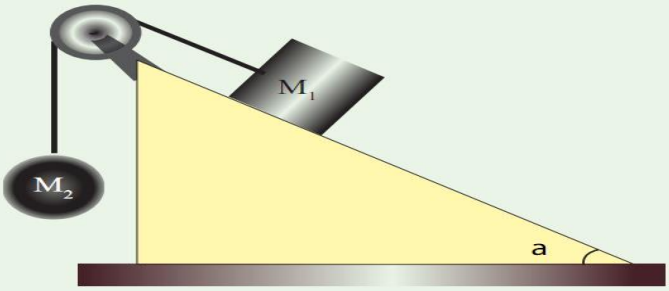

Figure 4.33: Two masses M_1 and M_2 connected together over a pulley at an incline

8. A small object A is suspended on a string of negligible mass of length OA=l making angle α with the vertical OB. One drops A without initial speed. Express, in function of l, g and α speed when it passes in B.

9. A car travelling with a speed of 180km/h strikes a wall. Find the height from which it will fall to produce the same energy.

($g = 10m/s^2$).

10. An object of 2kg falls freely during 5s. What is the kinetic energy? What will be the kinetic energy if the object is thrown downward with the speed of 4m/s? $g = 10m/s^2$

11. A small object A_0 of mass 50g is suspended by a string of 80cm of length of negligible mass. It's moved away from the equilibrium position to the point A. The angle A_0 OA being 60°, what is the change of the potential energy.

Linear momentum and impulse

1. What is the momentum of an 18.0g sparrow flying with a speed of 15.0m/s?

2. A moving object has an acceleration of $2.4m/s^2$. It reaches in 12s a momentum of 800kgm/s. Compute the mass of that object and the force acting on it.

3. An object of mass 200g slides without friction on a horizontal surface and strikes a vertical obstacle and moves back following the same direction with a speed of 11m/s Find the impulse.

4. A system is constituted by two masses m_1=2kg and m_2=0.5kg connected by a string. The system moves on a horizontal table without friction from the rest. One makes it in motion applying an impulse of 10Ns but the string is cut. The result is, m_2 moves away with a certain speed and m_1 with a speed of 2m/s what is the impulse received by m_1? by m_2? What is the speed of m_2 at the end of the impulse?

5. An object of mass m = 100g falls freely during 3s:

a) Find the received impulse, b) Deduce the change of the speed. c) Generalize to find the law of the free fall $h = 1/2\ gt^2$

6. One drops a ball of mass m from a height h_0 above the ground. The ball bounces till the point situated at the height h_1. Find the impulse received by the ball from the ground. Given that h_0= 2.55m, h_1= 2m, m = 0.2kg, g = 10m/s^2

7. A tennis ball of mass 200g is thrown horizontally with a speed of 15m/s toward the north. Assuming that the ball and the racket are in contact during 0.01s, find the force that the player has to exert to return it back with a speed of 25m/s,

a) Toward the south, b) Toward the south-east.

8. A 10,000kg railroad car travelling at a speed of 24.0m/s strikes an identical car at rest. If the cars lock together as result of collision, what is their common speed afterward?

9. Calculate the recoil back velocity of 4.0kg rifle which shoots a 0.050kg bullet at a speed of 280m/s.

Extension

1. Suppose you throw a bowl of 0.4kg on a wall in bricks. It strikes the wall rolling horizontally leftward at 30m/s and rebounds horizontally rightward at 20m/s.

a) Find the impulse of the force exerted on the bowl by the wall.

b) If the bowl remains in contact with the wall during 0.01s, find the average force exerted on the bowl at the time of impact.

2. An automobile of mass m = 749.5kg accelerates from the rest. During the first ten seconds, the net force acting on it is given by the relation $F = F_0 - kt$, where F_0= 888.6N, k = 44.48N/s and t is the time elapsed in second after the departure. Find the velocity at the end of the 10s and the travelled distance during that time.

3. A ball of mass 100g is dropped from a height h = 2m above the floor. It rebounds vertically to a height h' = 1.5m after colliding with the floor.

a) Find the momentum of the ball immediately before it collides with the floor and immediately after it rebounds.

b) Determine the average force exerted by the floor on the ball. Assume the time interval of the collision is 10^{-2} s.

Collisions

1. Two objects of masses m_1 and m_2 slide on a horizontal table without friction. The first has a speed $\overrightarrow{v_1}$ and the second has a speed $\overrightarrow{v_2}$ .They strike together. Assuming that the collision is elastic, find speeds and after collision in the following cases:

a)$\overrightarrow{v_1}$and $\overrightarrow{v_2}$have the same direction, b)$\overrightarrow{v_1}$and $\overrightarrow{v_2}$have opposite direction.

2. A proton travelling with a speed 8.2×10^5m/s collides elastically with a stationary proton in a hydrogen target. One of the protons is observed to be scattered at a 60° angle. At what angle will the second proton be observed, and what will be the velocities of the two protons after the collision?

3. A 15,000kg railroad car travels alone on a level frictionless track with a constant speed of 23m/s A 5000kg additional load is dropped onto the car. What then will be its speed?

4. A 90kg fullback is travelling 5.0m/s and is stopped by a tackler in 1s. Calculate

a) The original momentum of the fullback, b) The impulse imparted to the tackler c) The average force exerted on the tackler.

5. A billiard ball of mass m_A = 0.400kg moving with a speed v_A = 200m/s strikes a second ball, initially at rest, of mass m_B = 0.400kg. As a result of the collision, the first is deflected off at an angle of 30° with a speed of v_A = 1.20m/s.

a)Taking the x to be the original direction of motion of ball A, write down the equations expressing the conservation of momentum for the components in the x and y directions separately,

b) Solve these equations for the speed, V_B, and angle α; of ball B. Assume the collision is elastic.

6. Two billiard balls of equal mass move at right angles and meet at the origin of an xy coordinates system. One is moving upward along the y axis at 3m/s, the other is moving to the right angle along the x axis with a speed of 4.8m/s .After the collision (assumed elastic), the second ball is moving along the positive y axis. What is the final direction of the first ball, and what are their two speeds

An explosion breaks a block of stone in three pieces A, B and C of respective masses m_1, m_2 and m_3. Immediately after explosion the speeds v_1=15m/s, v_2=7m/s and v_3=50m/s Vectors $\overrightarrow{v_1}$ and $\overrightarrow{v_2}$ form a right angle. Assuming that m_1=1.5kg and m_2=3kg, determine the direction of $\overrightarrow{v_3}$ and m_3

7. Two masses m_1 = 5Kg and m_2 = 10Kg have velocities v_1 = 2m/s according to x positive axis and v_2 = 4m/s according to y positive axis. They collide and they get stuck. What is the final velocity after collision?

8. A lorry of transport of goods is empty and has a mass of 10000kg. When the lorry moves at 2m/s on a horizontal plane, it collides another lorry loaded, of total mass 20000kg; this last being initially at rest but with released breaks. If the two Lorries stuck together, after collision, what is their speed after collision?

a) With which velocity the loaded lorry must travel so that after collision the two remain at rest?

9. a) Distinguish between elastic collision and inelastic collision.

b) A ball of 0.1kg makes an elastic head-on collision with a ball of unknown mass that is initially at rest. If the 0.1kg ball rebounds at one third of its original speed, what is the mass of the other ball?

10. a) A 40g golf ball initially at rest is given a speed of 30m/s when a club (a specially shaped stick for striking a ball) strikes.

If the club and the ball are in contact for 1.5ms. What average force acts on the ball?

b) Is the effect of the ball's weight during the time of contact significant? Why or why not?

11. Two bodies A and B, having masses m_A and m_B, respectively, collide in a totally inelastic collision.

a) If body A has initial velocity v_A and B has initial velocity v_B, write down an expression for the common velocity of the merged bodies after the collision, assuming there are no external forces.

b) If $v_A = (5\vec{\imath} + 3\vec{\jmath})$ m/s and $v_B = (-\vec{\imath} + 4\vec{\jmath})$ m/s and mA = $3m_B/2$, show that the common velocity after the collision is

$v = (2.6\,\vec{\imath} + 3.4\,\vec{\jmath})$ m/s

c) Given that the mass of body A is 1200 kg and that the collision lasts for 0.2 s, determine the average force vectors acting on each body during the collision.

d) Determine the total kinetic energy after the collision.

12.A spring is used to stop a crate of mass 50 kg which is sliding on a horizontal surface. The spring has a spring constant k = 20 kN/m and is initially in its equilibrium state. In position A shown in the top diagram the crate has a velocity of 3.0m/s. The compression of the spring when the crate is instantaneously at rest (position B in the bottom diagram) is 120mm.

a) What is the work done by the spring as the crate is brought to a stop?

b) Write an expression for the work done by friction during the stopping of the crate (in terms of the coefficient of kinetic friction).

c) Determine the coefficient of friction between the crate and the surface.

d) What will be the velocity of the crate as it passes again through position, A after rebounding off the spring (Fig. 2.14a, b)?

Fig. 2.14a

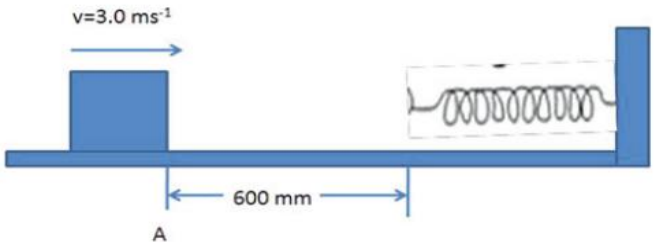

Fig. 2.14b