SECTION A *(45 marks)*

Attempt ALL questions.

A1. Explain why the Engineering Physics Course is relevant to your area of study. **[3]**

A2. Hooke's law states that the force, F, in a spring extended by a length x is given by $F = -kx$. From Newton's second law $F = ma$, where m is the mass and a is the acceleration, calculate the dimensions of the spring constant k. **[3]**

A3. Suppose that the uncertainty in the length $17.386\ 22\ m$ is $0.04\ m$. Round the length to the correct number of significant digits. **[2]**

A4. A female cheetah starts from rest and accelerates uniformly for 5 seconds until she reaches a velocity of $20\ m\ s^{-1}$while chasing a Thompson gazelle. She then runs at a constant velocity for 8 seconds before decelerating as she failed to catch the gazelle. Sketch a velocity-time graph of her motion. **[4]**

A5. A construction worker standing on a beam asks his very strong friend on the ground 9.00 m below to throw his lunch box up to him. The friend wants to throw the box straight up such that it has a velocity of 0.500 m/s up when it reaches the worker on the beam, to give him some leeway as he tries to catch it.

b) What assumption(s) should you make to solve the problem? **[2]**

c) At what speed should the friend throw the lunch box? **[3]**

d) How long will the lunch box be in the air before it is caught by the worker? **[2]**

e) How long does it take for the lunch box to cover the first 4.50 m of its trajectory? **[3]**

f) How high above its initial position will the lunch box be after half the total time of its motion? **[2]**

g) Sketch the distance-time, velocity-time, and acceleration-time graphs for the motion of the lunch box. **[4]**

A6. Two objects are moving at constant velocities: $\vec{V}_A = (2\hat{\imath} - 5\hat{\jmath})m/s$, $\vec{V}_B = (-2\hat{\imath} + 4\hat{\jmath})m/s$.

a) Which object is moving faster? **[3]**

b) Find the angle between objects' trajectories. **[3]**

A7. In Fig 1. a block of mass m_1 = 1.5 kg (**A)** on a plane inclined at $\theta = 30°$ (coefficient of friction = 0.15) is connected by a cord over a frictionless pulley to a second block **B** of mass m_2 = 3.00kg. Ignoring the mass of the pulley, determine

a) the magnitude of the acceleration of each block, **[4]**

b) the direction of the acceleration of the hanging block, and **[1]**

c) the tension in the cord. **[2]**

d) If the blocks are released from rest with the connecting cord taut, use the work kinetic energy theorem to determine the blocks total kinetic energy when block B has moved 30cm. **[4]**

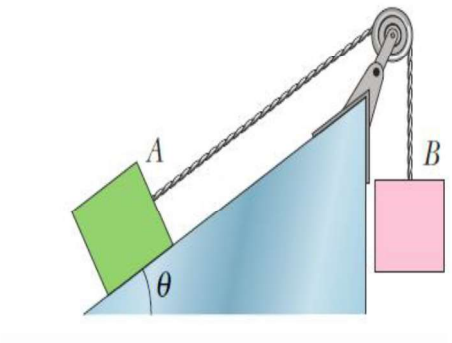


Figure 1

SECTION B *(35 marks)*

Answer question **B1** and **any other three** questions.

B1. (a) Define floating. **[2]**

(b) A cube of edge length $L = 0.600\ m$ and mass $450\ kg$ is suspended by a rope in an open tank of liquid of density $1030\ kg/m^3$, as shown in Fig 2.

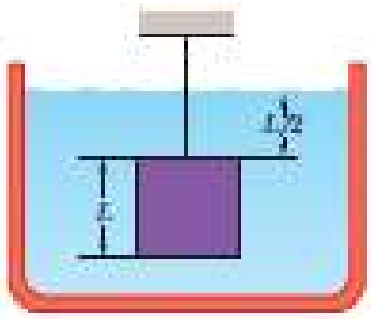


Figure 2

Find,

(i). the magnitude of the total downward force on the top of the cube from the liquid and the atmosphere, assuming atmospheric pressure is 1.00 atm, **[2]**

(ii). The magnitude of the total upward force on the bottom of the cube, **[2]**

(iii). The tension in the rope. **[2]**

(iv). The magnitude of the buoyant force on the cube using Archimedes' principle. **[3]**

B2.

a) Define resonance and describe one scenario where it is applied for the benefit of mankind. **[4]**

b) A block of mass $m = 14.00\ kg$ is released from rest on a frictionless incline of angle $\theta = 30°$, as shown in **Fig 3**. Below the block is a spring with spring constant, $k = 1800 N/m$. The block momentarily stops when it compresses the spring by 7.0 cm. Calculate the speed of the block just before compressing the spring. **[4]**

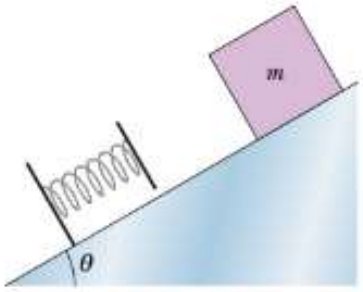


Figure 3

B3. (a). Calculate the difference in blood pressure (in atmosphere) between the heart and the foot in a person of height 2.00 *m* and the height from the heart to the head is 0.40 *m* and the density of blood is $1.06 \times 10^3 kg/m$. **[4]**

(b). The U-shape in Fig 4 contains two liquids in static equilibrium: water of density $998\ kg/m^3$ and an unknown liquid with unknown density. Find the density of the unknown liquid if $h = 155\ mm$ and $l = 135\ mm$. **[4]**

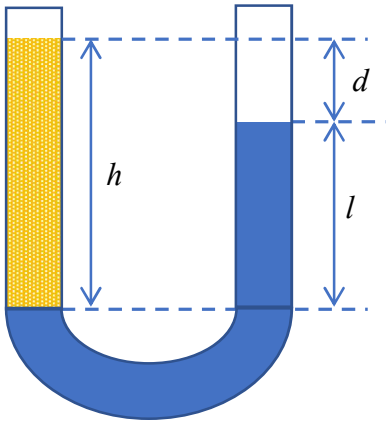


Figure 4

B4. A bat is flying at 7.00 m/s and is emitting cries at a frequency of 82.0 kHz. It is chasing a moth and is detecting the echoes from the moth. Moths fly somewhat erratically. Calculate the frequency detected by the bat when the moth is;

a) Stationary **[2]**

b) flying at 1.00 m/s in the same direction as the bat **[3]**

c) flying at 2.00 m/s toward the bat **[3]**

B5.

a) You went to the farm to do some sightseeing, then the workers ask you to measure the depth of a well. As an engineering student, you decide to show that you can use your intellect to determine the depth of the well to the amusement of the folks there. You drop a stone into the well and hear the splash 2.8 s later. Calculate the depth of the well. **[4]**

b) Consider the simplified single-piston engine in Fig 5. Assuming the wheel rotates with constant angular speed, explain why the piston rod oscillates in simple harmonic motion. **[4]**

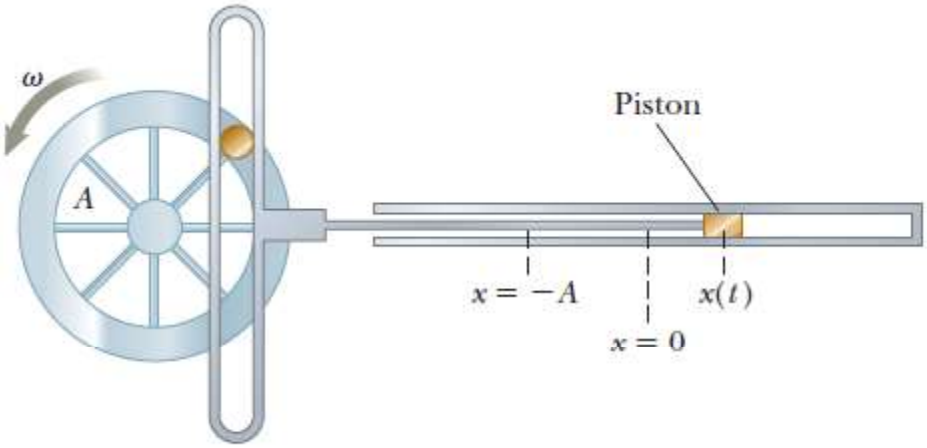


Figure 5

SECTION C *(20 marks)*

Answer question **C1 and any other three** questions.

C1. Draw a diagram showing the effects of both a converging lens on a beam of parallel rays. On the diagram clearly label the principle axis, principle focus, and focal length. **[8]**

C2. Good electrical conductors, such as metals, are typically good conductors of heat; electrical insulators, such as wood, are typically poor conductors of heat. Explain why there should be a relationship between electrical conduction and heat conduction in these materials. **[4]**

C3. An underwater scuba diver sees the Sun at an apparent angle of $45.0°$ above the horizontal. Calculate the actual elevation angle of the Sun above the horizontal. **[4]**

C4. A $+35.0\ nC$ charge is placed at the origin of a coordinate system, and a $-25.0\ nC$ charge is placed in the xy-plane at the point$(x = 0.100\ m, y = -0.0500\ m)$.

a) Determine the magnitude and the direction of the force that the positive charge exerts on the negative charge. Use ijk notation for your result. **[4]**

C5. A Referring to the circuit shown below in Fig 6, determine the number of;

a) nodes; **[1]**

b) elements; **[1]**

c) branches. **[1]**

d) loops **[1]**

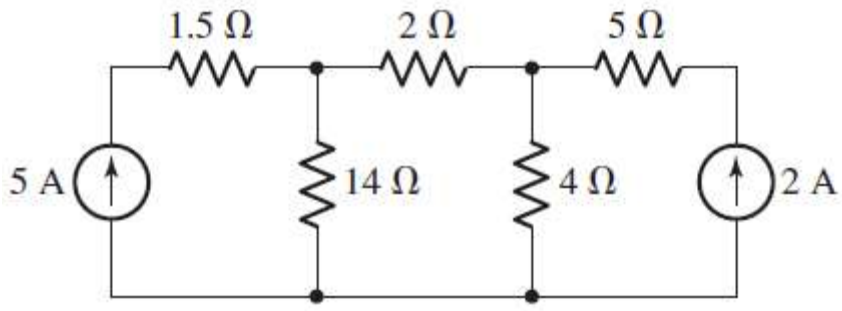


Figure 6

END OF EXAMINATION

SECTION A *(50 marks)*

Attempt **ALL** questions

A1. Explain the importance of dimensional analysis. [1]

A2. Certain stars, whose light and radial velocities undergo periodic vibrations, are thought to be pulsing. It is hypothesized that the period t of pulsation depends upon the star's radius, r, its mass, m, and the gravitational constant, G.

i. Compute the units of force from $F = ma$. [2]

ii. Newton's law of gravitation asserts that the attractive force between two bodies is proportional to the product of their masses divided by the distance between them:

$$F = G\frac{m_1 m_2}{r^2}$$

Compute the units of G from this. [4]

A3. Two vectors $\vec{a}$ and $\vec{b}$ have equal magnitudes of 12.0 m and the angles are $\theta_1 = 30°$ and $\theta_2 = 105°$ as shown in Fig. 1.

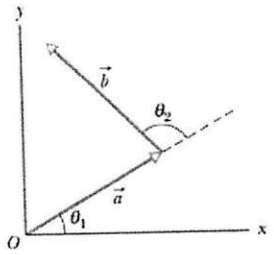


Fig. 1.

Find:

a. the magnitude of $\vec{r}$, and [3]
b. the angle that $\vec{r}$ makes with the positive direction of the x axis. [3]

A4. A certain airplane has a speed of $240.0\ km/h$ and is diving at an angle of $30.0°$ below the horizontal when the pilot releases a radar decoy as shown in Fig. 2.

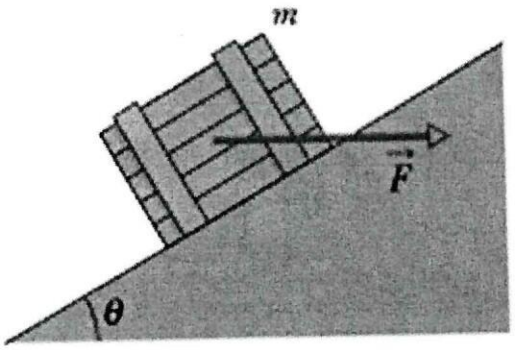


Fig. 4.

If the ramp has a coefficient of friction, $\mu = 0.20$,

i. Calculate the magnitude of the normal force [3]

ii. Calculate the force $\vec{F}$ [2]

A6.

a. Define work. [1]

b. Distinguish between conservative and no-conservative forces. [2]

c. A block of mass $m = 8.00\,kg$ is released from rest on a frictionless incline of angle $\theta = 30.0°$, as shown in Fig 5. Below the block is a spring that can be compressed $2.0\,cm$ by a force of 270 N. The block momentarily stops when it compresses the spring by 5.5 cm.

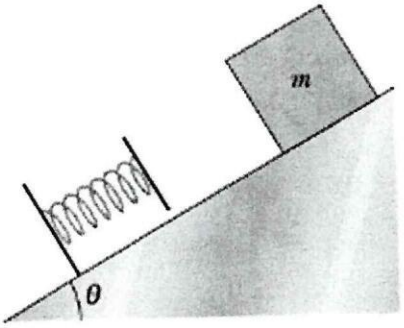


Fig 5.

i. Calculate the distance moved by the block down the incline from its rest position to this stopping point. [3]

ii. Calculate the speed of the block just as it touches the spring. [3]

c. A block of mass $m = 2.5\,kg$ slides head on into a spring of spring constant $k = 320\,N/m$ as shown in Fig. 6. When the block stops, it has compressed the

SECTION B *(30 marks)*

Answer all questions

B1. State

(i) Archimedes Principle

(ii) Pascal' s law [2]

B2. Give one important property for ANY four of the five main classes of engineering materials. [4]

B3. Differentiate between composition and atomic structure as applied in Materials science. [4]

B4.

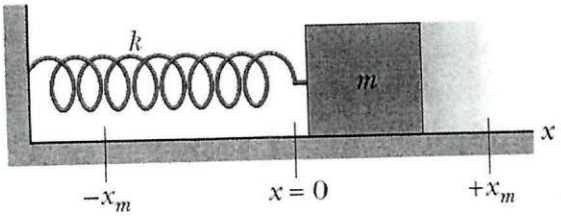


Fig 1. For Question 4.

At time $t = 0$, the displacement $x(0)$ of the block in a linear oscillator like that of Fig. 1 is -8.50 cm. The block's velocity $v(0)$ then is -0.93 m/s, and its acceleration $a(0)$ is 45.0 m/s^2 . Determine,

(i) the angular frequency of this system, [3]

(ii) the phase constant and [1]

(iii) the amplitude of this system. [1]

B5. While moving along a straight road, you first approach, and then pass a stationary car at the side of road. The car's horn is being continuously sounded. The frequency recorder you are carrying reads 638 Hz as you are approaching the car, and records 588 Hz as you recede from the car.

(i) Describe the Doppler Effect and give one example of its applications. [4]

(ii) Use the value of 340 m/s for the speed of sound in air in air to calculate your own speed and the frequency the occupant of the car hears. [6]

B6. A rectangular block of low density material weighs 20.0 N. A thin string is attached to the centre of the horizontal bottom of the block and tied to the bottom of a beaker partially filled with water. When 25% of the block's volume is submerged, the tension in the string is 10.0 N.

i. Calculate the buoyant force acting on the block. [3]

ii. Oil of density 800 kg/m^3 is steadily added, forming a layer above the water and surrounding the block. Explain why the addition of oil causes the string to break. [2]

SECTION A *(30 marks)*

Attempt **ALL** questions

A1. Explain the importance of dimensional analysis. [1]

A2. Certain stars, whose light and radial velocities undergo periodic vibrations, are thought to be pulsing. It is hypothesized that the period t of pulsation depends upon the star's radius, r, its mass, m, and the gravitational constant, G.

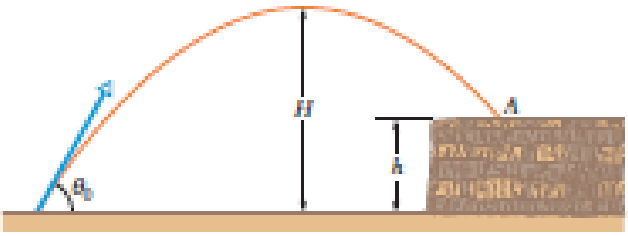
(i) Compute the units of force from $F = ma$. [2]

(ii) Newton's law of gravitation asserts that the attractive force between two bodies is proportional to the product of their masses divided by the distance between them:

$$F = G\frac{m_1 m_2}{r^2}$$

Compute the units of G from this. [3]

A3. A stone is projected at a cliff of height h with an initial speed of 42.0 m/s directed at angle $\theta = 60.0°$ above the horizontal. The stone strikes at A, 5.50 s after launching.



Find

(i) the height h of the cliff [2]
(ii) the speed of the stone just before impact at A, [3]
(iii) the maximum height H reached above the ground. [2]

A4. A constant horizontal force, $\vec{F}_a$ moves a 90 kg crate, 6.2 m up an inclined plane at a constant speed. The coefficient of kinetic friction between the crate and the inclined plane is 0.23. The angle between the inclined plane and the horizontal is θ.

(i) Draw a well labeled free-body diagram to illustrate this information. [3]
(ii) Show by calculation that the magnitude of $\vec{F}_a$ is given by,

$$F_a = \frac{mg(\sin\theta + \mu_k \cos\theta)}{\cos\theta - \mu_k \sin\theta}$$

[5]

(iii) Calculate the work done by $\vec{F}_a$ if $\theta = 30°$ [2]

(iv) Calculate the increase in thermal energy between the crate and the incline. [3]

A5. (a) A block of mass $m = 14.00\,kg$ is released from rest on a frictionless incline of angle $\theta = 30°$, as shown in **Fig 1**. Below the block is a spring with spring constant, $k = 1800N/m$. The block momentarily stops when it compresses the spring by 7.0 cm. Calculate the speed of the block just before compressing the spring. [3]

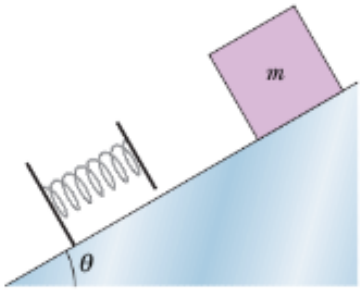


Fig 1.

(b) A $1200\,kg$ car is moving down a 20° inclined hill. At the time the car's speed is 14 m/s, the driver applies brakes. Calculate the magnitude of the kinetic frictional force if the car stops after traveling 100 m along the incline. [3]

(c) What do you understand by the term *elastic collision*. [1]

(d) A body of mass $2.0\,kg$ makes an elastic collision with another body at rest and continues to move in the original direction but with one-fourth of its original speed. Calculate the mass of the other body. [2]

SECTION B *(40 marks)*

Answer all questions

B1. (a). Calculate the difference in blood pressure (in atmosphere) between the heart and the foot in a person of height 2.00 m and the height from the heart to the head is 0.40 m and the density of blood is $1.06 \times 10^3 kg/m$. [2]

(b). The U-shape in Fig 2 contains two liquids in static equilibrium: water of density $998\ kg/m^3$ and an unknown liquid with unknown density. Find the density of the unknown liquid if $h = 155\ mm$ and $l = 135\ mm$. [3]

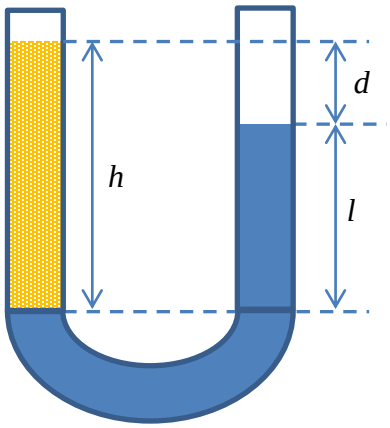


Fig 2

B2. (a) Define floating. [1]

(b) A cube of edge length $L = 0.600\ m$ and mass $450\ kg$ is suspended by a rope in an open tank of liquid of density $1030\ kg/m^3$, as shown in Fig 3.

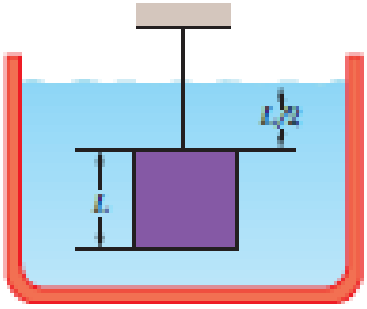


Fig 3

Find,

(i). the magnitude of the total downward force on the top of the cube from the liquid and the atmosphere, assuming atmospheric pressure is 1.00 atm, [2]
(ii). The magnitude of the total upward force on the bottom of the cube, [2]
(iii). The tension in the rope. [2]
(iv). The magnitude of the buoyant force on the cube using Archimedes' principle. [3]

B3. (a) State Pascal's principle. [1]

(b) Hence or otherwise, show that for a hydraulic lever, the output work done, *W* is given by,

$$W = F_o d_o = F_i d_i$$

[3]

(c) A spring of spring constant $3.00 \times 10^4\ N/m$ is between a rigid beam and the output piston of a hydraulic lever. An empty container with negligible mass sits on the input piston. The input piston has area A_i, and the output piston has area $18.0A_i$. Initially the spring is at its rest length. How many kilograms of sand must be (slowly) poured into the container to compress the spring by $5.00\ cm$? [3]

B4. A garden hose with an internal diameter of 1.9 cm is connected to a (stationary) lawn sprinkler that consists merely of a container with 24 holes, each 0.13 cm in diameter. If the water in the hose has a speed of 0.91 m/s, at what speed does it leave the sprinkler holes? [3]

B5.

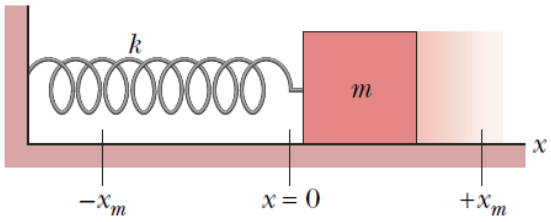


Fig 4.

At time $t = 0$, the displacement $x(0)$ of the block in a linear oscillator like that of Fig. 4 is $-8.50\ cm$. The block's velocity $v(0)$ then is $-0.93\ m/s$, and its acceleration $a(0)$ is $45.0\ m/s^2$. Determine,

(i) the angular frequency of this system, [3]
(ii) the phase constant and [1]
(iii) the amplitude of this system. [1]

B6. The displacement function for a pulse travelling along a string is given by the equation

$$D(x,t) = \frac{4.0}{(x-2t)^2 + 6.0}$$

where *x* is in metres and *t* is in seconds.

a) Determine the speed of the pulse, and the direction in which is it travelling [2]
b) Calculate the displacement of a point located at $x = 4.0\ m$ at $t = 1.0\ s$ [2]
c) Calculate the speed of a point that is located at $x = 5.0\ m$ at t=1.0 s [2]
d) Determine the maximum displacement of a point as the pulse passes through it. [1]

B7. A police siren emits a frequency of 700.0 Hz. When the police car approaches you at a speed of 80.0 km/h, determine the frequency you perceive? (Take the value of the speed of sound in air to be $330 ms^{-1}$) [3]

SECTION C *(30 marks)*

Answer all questions

C1. Ordinary window glass reflects approximately 4% of incident light and transmits the remaining 96%. Use this information to explain why ordinary window glass works like a mirror for a person inside the house at night but looks transparent during the day. Remember, the light entering the glass encounters two boundaries: an air–glass boundary upon entering the glass pane and a glass–air boundary at the exit. [3]

C2. An observer is positioned so that the far edge of the bottom of an empty glass is just visible (Figure 1 below). When the glass is filled to the top with water, the centre of the bottom of the glass is just visible to the observer. The width of the glass is 6.8 cm.

a) What is the height, h, of the glass? [3]

b) What does the observer see when the glass is filled with oil instead of water? [2]

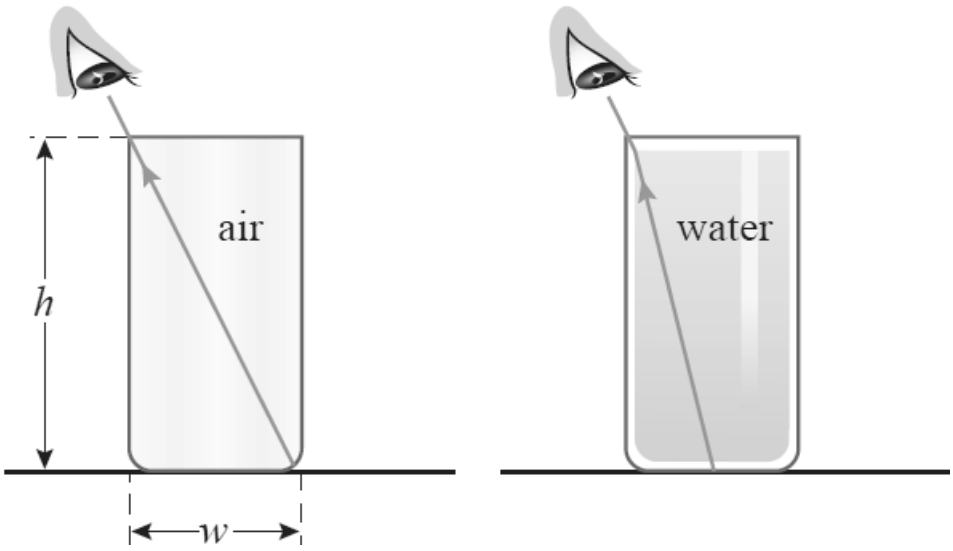


Fig 5.

C3. On a car's side-view mirror you notice a warning: "Objects in mirror are closer than they appear." Explain the physics behind this statement. What kind of mirror is it, and why is it used as a side-view mirror? [3]

C4. A $+30.0\,nC$ charge is placed at the origin of a coordinate system, and a $-50.0\,nC$ charge is placed in the xy-plane at the point($x = 0.100\,m, y = -0.500\,m$).

a) Determine the magnitude and the direction of the force that the positive charge exerts on the negative charge. Use ijk notation for your result. [3]

b) Determine the magnitude and direction of the force of the negative charge on the positive charge. [3]

C5. Good electrical conductors, such as metals, are typically good conductors of heat; electrical insulators, such as wood, are typically poor conductors of heat. Explain why there should be a relationship between electrical conduction and heat conduction in these materials. [3]

C6. Determine the resistance of an electric fire which takes a current of 12A from a 240V supply. Find also the power rating of the fire and the energy used in 20 h. [3]

C7. Referring to the circuit shown below (figure 6), determine the number of;

a) nodes; [1]

b) elements; [1]

c) branches. [1]

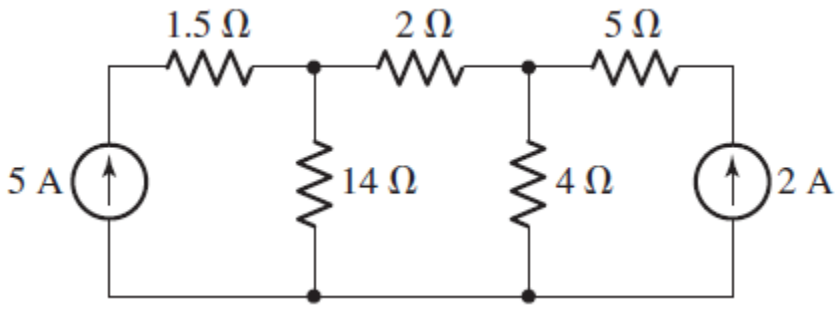


Fig 6.

C8. Use Thevenin's theorem to find the current through the 2 Ω resistor in the circuit shown below. [4]

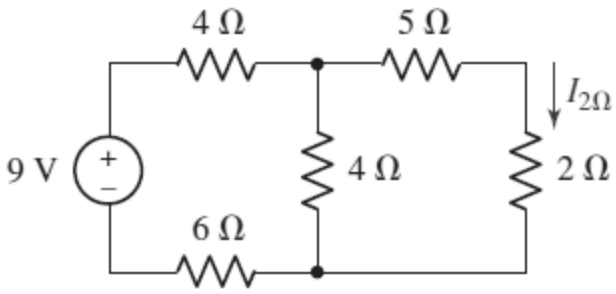


Fig 7.

END OF EXAMINATION

SECTION A *(30 marks)*

Attempt ALL questions

A1. Explain the importance of dimensional analysis. **[1]**

A2. How many significant figures are in:

a) 23,000 **[1]**
b) 30000.00 **[1]**
c) 0.0003356 **[1]**

A3. The figure 1 below shows a plot of the position versus time for two objects.

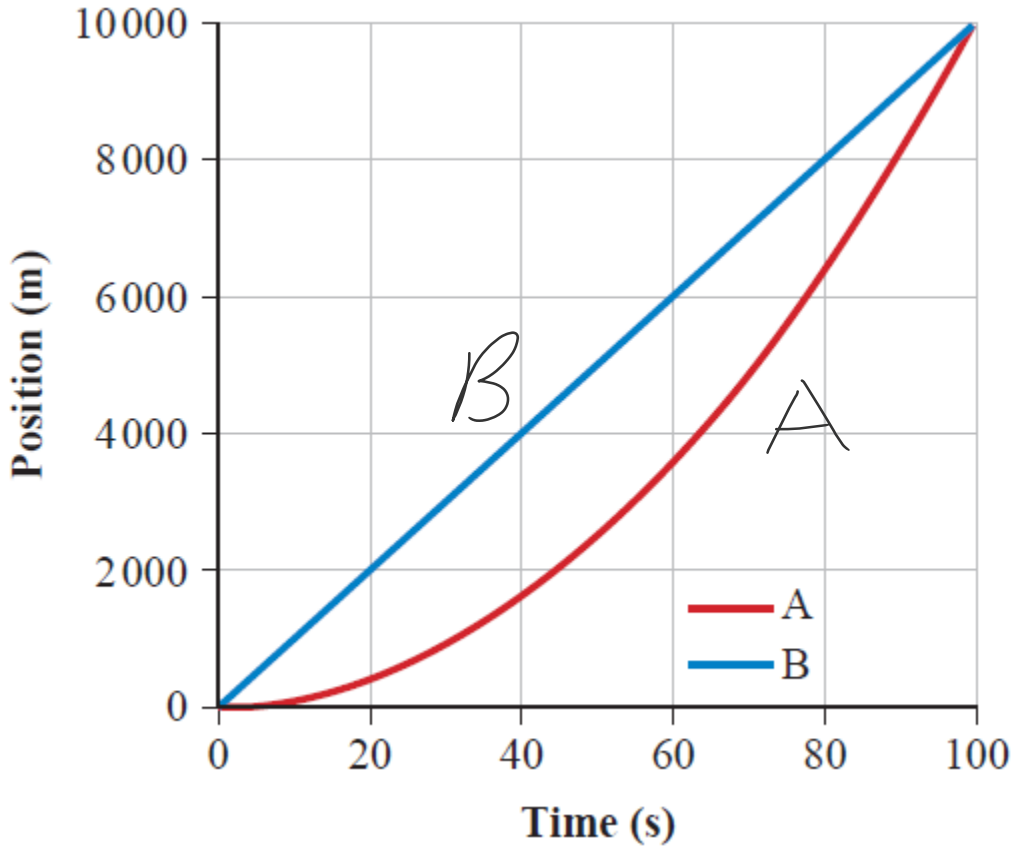


Figure 1

a) Which object has the higher average velocity for the interval shown? **[2]**
b) Which object has the higher speed at $t = 30\ s$? **[2]**
c) Which has the higher speed at $t = 90\ s$? **[2]**

d) Do the objects ever have the same speed? If so, at what time do you estimate this will happen? **[3]**

A4. A block whose mass m is 550 g is fastened to a spring whose spring constant k is $55\ N/m$. The block is pulled a distance $x = 10$ cm from its equilibrium position at $x = 0$ on a frictionless surface and released from rest at $t = 0$.

a) What are the angular frequency, the frequency, and the period of the resulting motion? **[3]**
b) What is the amplitude of the oscillation? **[2]**
c) What is the maximum speed v_m of the oscillating block, and where is the block when it has this speed? **[2]**
d) What is the magnitude a_m of the maximum acceleration of the block? **[2]**

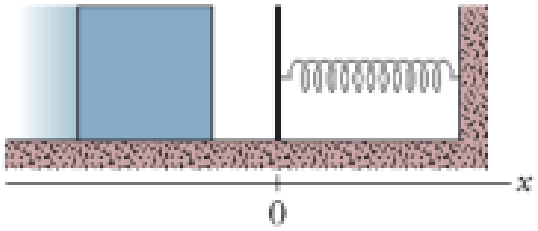


Figure 2

A5. Define work done by a force. **[2]**

A6. An mine elevator carries 11 miners of average mass 60 kg to a height of 70 meters from their shaft level in two minute.

a) Calculate the work done in lifting the passengers **[3]**
b) Calculate the power needed to do that task **[3]**

SECTION B *(45 marks)*

Answer all questions

B1. Calculate the difference in blood pressure (in atmosphere) between the heart and the foot in a person of height 1.80 m and the height from the heart to the head is 0.40 m and the density of blood is $1.06 \times 10^3 kg/m$. **[3]**

B2. A bloc of density 4000kg/m^3 and volume of 0.002m^3 is immersed in water (density 1000kg/m^3). Calculate:

a) The upward force exerted by the fluid on the object **[2]**
b) The weight of the object in air **[2]**
c) Its weight inside the fluid **[3]**

B3. Consider a horizontal pipe with a constriction in its middle section. The diameter of the pipe is 10 cm at both ends and 5 cm at the constriction. The pressure at the left end of the pipe is 200 kPa and the fluid velocity is 2 m/s. Assuming steady, incompressible and inviscid flow, apply Bernoulli's principle to find the pressure and the velocity at the constriction **[4]**

B4. Some wire of cross-sectional area 6mm^2 has a resistance of 250Ω. Determine:

a) the resistance of a wire of the same length and material if the cross-sectional area is $10mm^2$, and **[2]**
b) the cross-sectional area of a wire of the same length and material if the resistance is 50Ω. **[2]**

B5. Light is a form of electromagnetic radiation and can move from one medium to another.

a) State Snell's law of refraction **[2]**
b) Find the critical angle for an air-water boundary. (Assume the index of refraction of water is 1.33.) **[3]**
c) State two applications in which total internal reflection is useful. **[2]**

B6. The displacement function for a pulse passing through a string is given by.

$D(x,t) = \frac{4.0}{8.0+(x-2.0t)^2}$ where $\boldsymbol{x}$ and $\boldsymbol{D}$ are in metres and $\boldsymbol{t}$ is in seconds.

a) Calculate the speed of the pulse, and in which direction is it travelling **[2]**
b) Calculate the displacement of a point located at $\boldsymbol{x = 2.0\ m}$ at $\boldsymbol{t = 3.0s}$ **[2]**
c) Calculate the maximum displacement of a point on the string **[3]**
d) Calculate the transverse speed of a point that is located at $\boldsymbol{x = 2.0\ m}$ at $\boldsymbol{t = 3.0s}$ **[3]**

e) Sketch a displacement versus position (x) graph for $\boldsymbol{t = 0s, 1s, 2s}$, and $\boldsymbol{3s}$ for this waveform. **[2]**

B7. What is the doppler effect. **[2]**

b) how does it affect the frequency of sound or light waves perceived by an observer moving relative to the source? **[3]**

c) Consider a car that is moving towards a stationary observer with a constant speed of 20 m/s. The car emits a sound with a frequency of 500 Hz. What is the frequency of the sound heard by the observer? **[3]**

Assume the speed of sound in air is 340 m/s.

SECTION C *(25 marks)*

Answer all questions

C1. Using sketches were necessary, explain Kirchhoff's current Law. **[2]**

C2. Using sketches were necessary, explain Kirchhoff's Voltage Law **[2]**

C3. Referring to the circuit shown below (Fig. 3), determine the number of.

a) branches **[1]**
b) nodes **[1]**
c) loops **[1]**

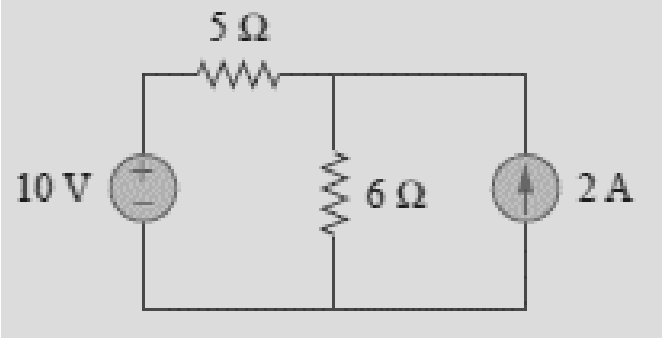


Figure 3

C4. Using the knowledge you have of electrostatic charges, with aid of sketches, describe in detail the process that leads to a lighting discharge. **[4]**

C5. Consider a $2\mu C$ charge located at the origin and a $-4\mu C$ located on the x axis at x=0.002m.

a) Determine the electric force exerted by the $2\mu C$ charge on the $-4\mu C$ charge. **[3]**
b) Determine the electric force exerted by the $-4\mu C$ on the $2\mu C$ charge. **[3]**

C6. Determine the electric field at the point (0.004,0.005) due to a $-6\mu C$ point charge located at the origin. **[4]**

C7. You are designing a satellite that will orbit the Earth for several years. What kind of materials would you use for the outer shell and why? Consider the factors such as thermal expansion, corrosion, radiation, and weight. **[4]**

C8. Explain what is meant by minority and majority carriers in an n-type material and state whether the numbers of each of these carriers are affected by temperature. **[3]**

END OF EXAMINATION

SECTION A *(40 marks)*

Attempt ALL questions

A1. Explain the importance of dimensional analysis. **[1]**

A2. Certain stars, whose light and radial velocities undergo periodic vibrations, are thought to be pulsing. It is hypothesized that the period t of pulsation depends upon the star's radius, r, its mass, m, and the gravitational constant, G.

a) Compute the units of force from $F = ma$. **[2]**

b) Newton's law of gravitation asserts that the attractive force between two bodies is proportional to the product of their masses divided by the distance between them:

$$F = G\frac{m_1 m_2}{r^2}$$

Compute the units of G from this. **[4]**

A3. Two vectors $\vec{a}$ and $\vec{b}$ have equal magnitudes of 12.0 m and the angles are $\theta_1 = 30°$ and $\theta_2 = 105°$ as shown in Fig. 1.

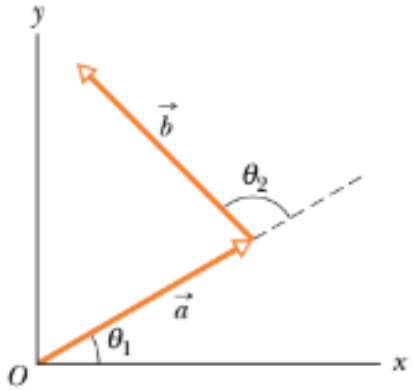


Fig. 1.

Find:

a) the magnitude of $\vec{r}$, and **[3]**

b) the angle that $\vec{r}$ makes with the positive direction of the x axis. **[3]**

A4. A crate of mass $m = 75\ kg$ is pushed at constant speed up a ramp inclined at 30.0° by a horizontal force as shown in Fig. 2.

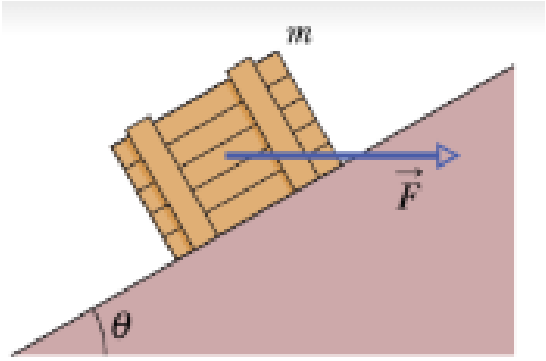


Fig. 2.

If the ramp has a coefficient of friction, $\mu = 0.20$,

a) Calculate the magnitude of the normal force **[3]**

b) Calculate the force $\vec{F}$ **[2]**

A5. Define work. **[2]**

b) Distinguish between conservative and no-conservative forces. **[2]**

c) A block of mass m=5.00 kg is released from rest on a frictionless incline of angle θ=30.0°, as shown in Fig 3. Below the block is a spring that can be compressed 4.0 cm by a force of 300 N. The block momentarily stops when it compresses the spring by 6.5 cm.

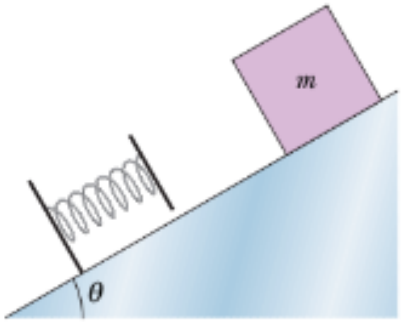


Fig 3.

d) Calculate the distance moved by the block down the incline from its rest position to this stopping point. **[3]**

e) Calculate the speed of the block just as it touches the spring. **[3]**

A6. What do you understand by the term *elastic collision*. **[2]**

b) A body of mass $3.0\ kg$ makes an elastic collision with another body at rest and continues to move in the original direction but with one-fourth of its original speed. Calculate the mass of the other body. **[4]**

A7. A stone is projected at a cliff of height *h* with an initial speed of 12.0 *m/s* directed at angle $\theta = 30.0°$ above the horizontal as shown in Fig 4. The stone strikes at *A*, 7.50 *s* after launching.

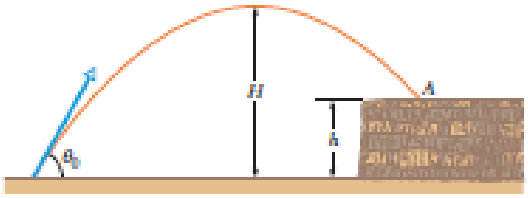


Fig 4.

Find

a) the height *h* of the cliff **[2]**

b) the speed of the stone just before impact at A, **[2]**

c) the maximum height *H* reached above the ground. **[2]**

SECTION B *(35 marks)*

Answer all questions

B1. A hypodermic syringe contains a medicine with the density of water (Fig.5). The barrel of the syringe has a cross-sectional area $A = 2.5 \times 10^{-5} m^2$, and the needle has a cross-sectional area $a = 1.0 \times 10^{-8} m^2$. In the absence of a force on the plunger, the pressure everywhere is $1.00\ atm$. A force $\vec{F}$ of magnitude $2.00\ N$ acts on the plunger, making medicine squirt horizontally from the needle. Determine the speed of the medicine as it leaves the needle's tip. **[4]**

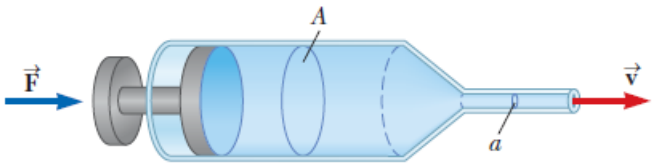


Fig 5.

B2. Give an example of an application of Bernoulli's principle in engineering or everyday life. **[3]**

B3. What is Archimedes' principle and how can it be used to determine the buoyant force on an object submerged in a fluid? **[3]**

B4. A bloc of density $5000 kg/m^3$ and volume of $0.003 m^3$ is immersed in water (density $1000 kg/m^3$). Calculate:

a) The upward force exerted by the fluid on the object **[2]**
b) The weight of the object in air **[2]**
c) Its weight inside the fluid **[2]**

B5. A 55 kg woman wearing high-heeled shoes is invited into a home in which the kitchen has vinyl floor covering. The heel on each shoe is circular and has a radius of 0.500 cm.

a) If the woman balances on one heel, what pressure does she exert on the floor? **[3]**

b) Should the homeowner be concerned? Explain your answer. **[3]**

B6. Light is a form of electromagnetic radiation and can move from one medium to another.

a) State Snell's law of refraction **[2]**
b) Find the critical angle for an air-water boundary. (Assume the index of refraction of water is 1.33.) **[3]**
c) State two applications in which total internal reflection is useful. **[2]**

B7. What is the doppler effect. **[2]**

b) Your phone alarm clock awakens you with a steady and irritating sound of frequency 650 Hz. One morning, on the day of exams, it malfunctions and cannot be turned off. In frustration, you drop the phone out of your three-story hostel window, 12.0 m from the ground. Assume the speed of sound is 343 m/s. As you listen to the falling phone, what frequency do you hear just before you hear it striking the ground? **[4]**

SECTION C *(25 marks)*

Answer all questions

C1. Using sketches were necessary, explain Kirchhoff's current Law. **[2]**

C2. Using sketches were necessary, explain Kirchhoff's Voltage Law **[2]**

C3. Referring to the circuit shown below (Fig. 6), determine the number of.

a) branches **[1]**
b) nodes **[1]**
c) loops **[1]**

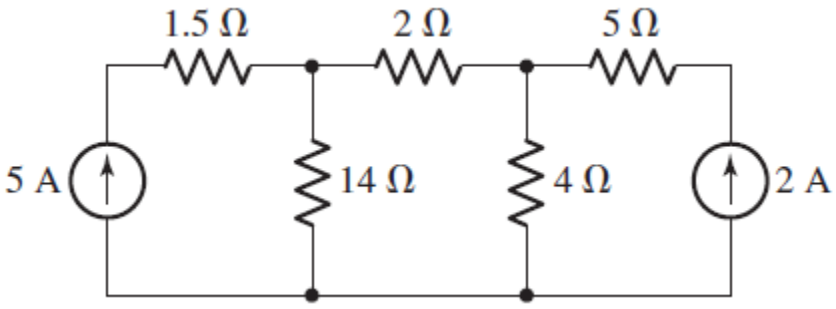


Fig 6.

C4. A capacitor that has two parallel plates of dimensions 15.00cm ×7.50 cm separated by 1.00 mm of air is connected to a 12.0 V battery. Find

a) the capacitance **[2]**
b) the charge on one plate **[2]**
c) the electric field in the capacitor **[2]**

C5. Consider a 4μC charge located at the origin and a −6μC located on the x axis at x=0.002m.

a) Determine the electric force exerted by the 4μC charge on the −6μC charge. **[3]**
b) Determine the electric force exerted by the −6μC on the 4μC charge. **[2]**

C6. Determine the electric field at the point (0.003,0.004) due to a −5μC point charge located at the origin. **[4]**

C7. Explain what is meant by minority and majority carriers in an p-type material and state whether the numbers of each of these carriers are affected by temperature. **[3]**

END OF EXAMINATION

SECTION A *(55 marks)*

Attempt ALL questions

A1. Explain:

a. the importance of SI units and standards in measurements. **[2]**
b. the importance of dimensional analysis. **[2]**

A2. In fluid mechanics, the *Reynolds number* is a dimensionless number involving fluid velocity v, density ρ, viscosity μ and a characteristic length r. Some of the dimensions of the quantities are given in the table below,

Variable	v	ρ	μ	r
Dimension		ML^{-3}	$ML^{-1}T^{-1}$	

a. Fill in the missing dimensions in the table. **[3]**
b. Hence or otherwise, find this dimensionless number as a product of the variables given in the table above. **[5]**

A3. A certain airplane has a speed of $240.0\ km/h$ and is diving at an angle of $30.0°$ below the horizontal when the pilot releases a radar decoy as shown in Fig. 1.

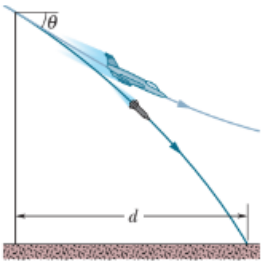


Fig. 1.

The horizontal distance between the release point and the point where the decoy strikes the ground is $d = 700\ m$.

a. How high was the release point? **[3]**
b. What is the speed of the decoy just before it hits the ground? **[3]**

A4. State:

a. Newton's first law. **[1]**
b. Newton's Second law. **[1]**
c. There are two forces on the 1.50 kg box in the overhead view of Fig. 2, but only one is shown.

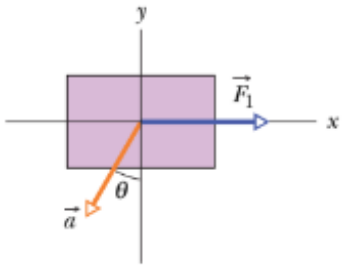


Fig. 2.

For $F_1 = 25.0\ N$, $a = 10.0\ m/s^2$, and $\theta = 25.0°$, find the second force

i. In unit-vector notation and **[2]**
ii. as a magnitude and **[1]**
iii. an angle relative to the positive direction of the x axis. **[2]**

A5. A crate of mass $m = 55\ kg$ is pushed at constant speed up a ramp inclined at 35.0° by a horizontal force as shown in Fig. 3.

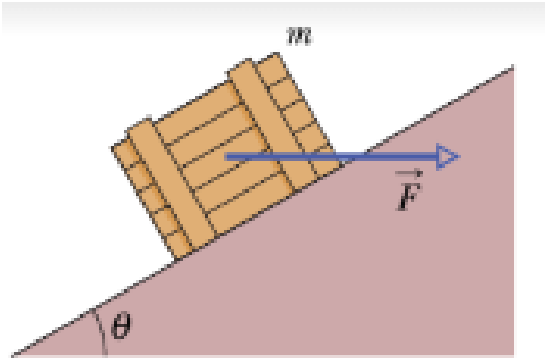


Fig. 3.

If the ramp has a coefficient of friction, $\mu = 0.05$

a. Calculate the magnitude of the normal force **[3]**
b. Calculate the force $\vec{F}$ **[2]**

A6. Define work. **[2]**

a. Distinguish between conservative and no-conservative forces. **[2]**

A7. A block of mass m=4.00 kg is released from rest on a frictionless incline of angle θ=35.0°, as shown in Fig 4. Below the block is a spring that can be compressed 4.0 cm by a force of 300 N. The block momentarily stops when it compresses the spring by 6.5 cm.

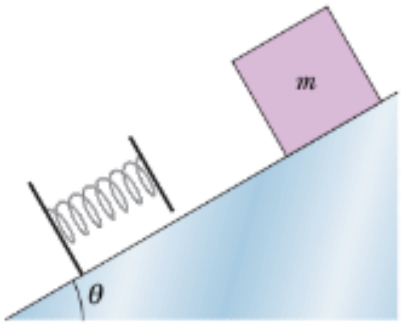


Fig 4.

a. Calculate the distance moved by the block down the incline from its rest position to this stopping point. **[3]**

b. Calculate the speed of the block just as it touches the spring. **[3]**

A8. What do you understand by the term *elastic collision*. **[2]**

b) A body of mass $3.0\ kg$ makes an elastic collision with another body at rest and continues to move in the original direction but with one-fourth of its original speed. Calculate the mass of the other body. **[4]**

A9. A block whose mass m is 750 g is fastened to a spring whose spring constant k is $55\ N/m$ (Fig 5.). The block is pulled a distance $x = 5$ cm from its equilibrium position at $x = 0$ on a frictionless surface and released from rest at $t = 0$.

a. What are the angular frequency, the frequency, and the period of the resulting motion? **[3]**

b. What is the amplitude of the oscillation? **[2]**

c. What is the maximum speed v_m of the oscillating block, and where is the block when it has this speed? **[2]**

d. What is the magnitude a_m of the maximum acceleration of the block? **[2]**

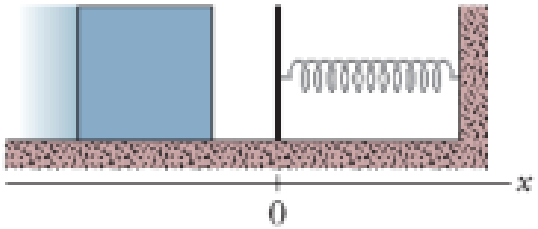


Fig 5.

SECTION B *(30 marks)*

Answer all questions

B1. State

a. Pascal's Law **[2]**

b. Archimedes Principle **[2]**

B2. Give an example of an application of Bernoulli's principle in engineering or everyday life. **[3]**

B3. What is Archimedes' principle and how can it be used to determine the buoyant force on an object submerged in a fluid? **[3]**

B4. A bloc of density $4000 kg/m^3$ and volume of $0.004 m^3$ is immersed in water (density $1000 kg/m^3$). Calculate:

a. The upward force exerted by the fluid on the object **[2]**
b. The weight of the object in air **[2]**
c. Its weight inside the fluid **[2]**

B5. The displacement function for a pulse passing through a string is given by.

$D(x,t) = \frac{2.0}{4.0+(x-2.0t)^2}$ where $\boldsymbol{x}$ and $\boldsymbol{D}$ are in metres and $\boldsymbol{t}$ is in seconds.

a. Calculate the speed of the pulse, and in which direction is it travelling **[2]**
b. Calculate the displacement of a point located at $\boldsymbol{x = 2.0\ m}$ at $\boldsymbol{t = 3.0 s}$ **[2]**
c. Calculate the maximum displacement of a point on the string **[3]**
d. Calculate the transverse speed of a point that is located at $\boldsymbol{x = 2.0\ m}$ at $\boldsymbol{t = 3.0 s}$ **[3]**
e. Sketch a displacement versus position (x) graph for $\boldsymbol{t = 0 s, 1 s, 2 s}$, and $\boldsymbol{3 s}$ for this waveform. **[2]**

B6. What is the doppler effect. **[2]**

SECTION C *(15 marks)*

Answer all questions

C1. Using sketches were necessary, explain Kirchhoff's current Law. **[2]**

C2. Using sketches were necessary, explain Kirchhoff's Voltage Law **[2]**

C3. Referring to the circuit shown below (Fig. 6), determine the number of.

a. branches **[1]**
b. nodes **[1]**
c. loops **[1]**

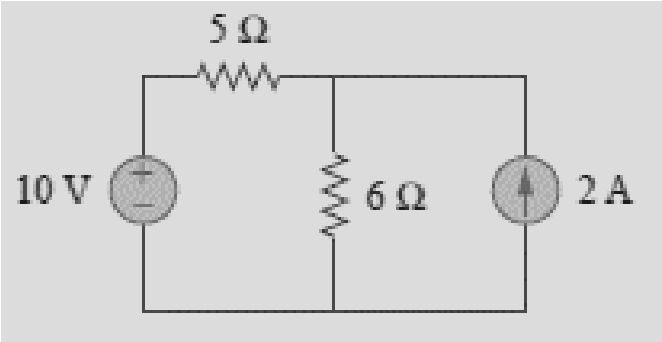


Fig 6.

C4. Using the knowledge you have of electrostatic charges, with aid of sketches, describe in detail the process that leads to a lighting discharge. **[4]**

C5. During an eye exam, you notice that to be able to read a book, you have to hold it 12 cm in front of your eyes. For a healthy eye, this distance should be approximately 25 cm.

a. What vision problem does this indicate? **[2]**
b. What further information do you need to determine the optical power of eyeglasses to correct your vision? **[2]**

END OF EXAMINATION

SECTION A *(35 marks)*

Attempt ALL questions.

A1. What are the dimensions of force in terms of mass (M), length (L) and time (T)**[2]**

A2. You measure the length of a rod using a ruler and obtain the value 11.34 cm. The ruler has an uncertainty of ±0.05 cm. Describe how will you report the result of the measurement, taking into account the significant figures and the uncertainty **[3]**

A3. $\boldsymbol{A} = 4i - 3j + 5k$ and $\boldsymbol{B} = -3i + 7j - 5k$, determine the magnitude and direction of their cross-product $\boldsymbol{A} \times \boldsymbol{B}$. **[3]**

A4. A cyclist starts from rest and accelerates uniformly at $3ms^{-2}$ for 10 seconds, then maintains a constant speed for another 15 seconds. Finally, the cyclist decelerates uniformly at $6ms^{-2}$ until it stops. Calculate the total distance travelled by the cyclist? **[3]**

A5. A projectile is launched from the ground at an angle of $45°$ above the horizontal with an initial speed of $25ms^{-1}$. Neglecting air resistance, calculate,

a. the maximum height, **[2]**

b. the time of flight and, **[2]**

c. the horizontal range of the projectile. **[2]**

A6. In figure 1, the pulley has negligible mass, and both it and the inclined plane are frictionless. Block A has a mass of 1.0 kg, block B has a mass of 2.0 kg, and angle θ is 30°. If the blocks are released from rest with the connecting cord taut, calculate their total kinetic energy when block B has fallen 25 cm? **[4]**

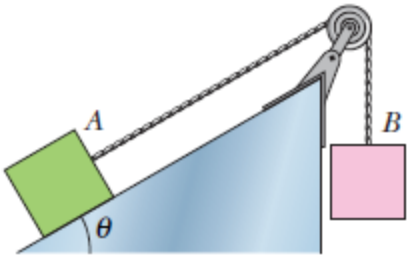


Figure 1

A7. A skydiver of mass 70 kg jumps out of a plane at a height of 3000 m. He opens his parachute at a height of 1000 m. Assume that the air drag force on the skydiver is proportional to the square of his speed, i.e., $F = -kv^2$, where k is a constant. The terminal velocity of the skydiver without the parachute is 60 m/s, and with the parachute is 15 m/s. Calculate,

a. the value of k and, **[2]**

b. the time taken by the skydiver to reach the ground. **[2]**

A8. A roller coaster car of mass 500 kg starts from rest at a height of 50 m. It slides down a track and reaches a height of 20 m at point A. Then it goes through a loop of radius 10 m and reaches point B at the top of the loop. Neglecting friction and air resistance, calculate,

a. the speed of the car at points A and B, and **[3]**

b. the normal force exerted by the track on the car at point B. **[3]**

A9. A boy of mass 55 kg running at 5 m/s jumps on to a 15 kg trolley travelling in the same direction at $2ms^{-1}$. Calculate their common velocity. **[4]**

SECTION B *(40 marks)*

Answer all questions.

B1. Your friend asks you to determine whether the ring that she recently bought is made of pure gold. (The density of gold is $1.93 \times 10^4\ kg/m3$.) Using a thread of negligible mass and volume, you tie the ring to a very accurate spring balance and determine that in air it weighs $6.40 \times\ 10^{-3}\ N$. You then fully immerse the ring in a beaker full of water and find that its apparent weight is $6.00\ \times 10^{-3}\ N$. Determine if the ring is made of pure gold. **[4]**

B2. A 60.0-kg woman wearing high-heeled stilettos is invited into a home in which the kitchen has vinyl floor covering. The heel on each shoe is circular and has a radius of 0.5cm. If the woman balances on one heel, calculate the,

a. pressure does she exert on the floor, **[2]**
b. Should the homeowner be concerned, **[2]**
c. Explain your answer on b. **[2]**

B3. A water pipe having a 2.5 cm inside diameter carries water into the basement of a house at a speed of 0.90 m/s and a pressure of 170 kPa. If the pipe tapers to 1.2 cm and rises to the second floor 7.6 m above the input point, Determine the.

a. speed and **[2]**
b. water pressure on the second floor. **[3]**

B4. A block whose mass m is 680 g is fastened to a spring whose spring constant k is 65 N/m as shown in figure 2 below. The block is pulled a distance $x = 11$ cm from its equilibrium position at $x = 0$ on a frictionless surface and released from rest at $t = 0$.

a. What is the angular frequency, the frequency, and the period of the resulting motion? **[3]**
b. What is the amplitude of the oscillation? **[1]**

c. What is the maximum speed v_m of the oscillating block, and where is the block when it has this speed? **[2]**

d. What is the magnitude a_m of the maximum acceleration of the block? **[2]**

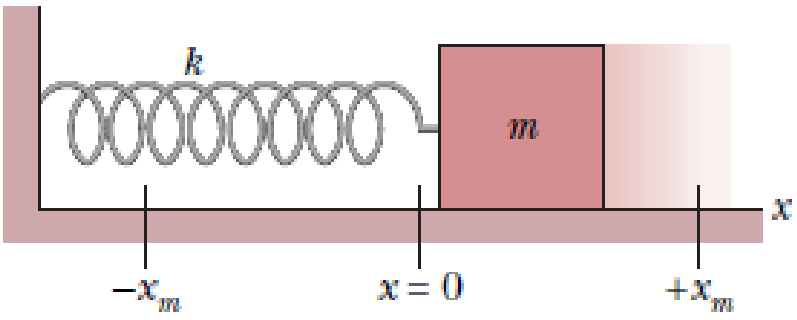


Figure 2

B5. Consider the simplified single-piston engine in figure 3. Assuming the wheel rotates with constant angular speed, explain why the piston rod oscillates in simple harmonic motion. **[4]**

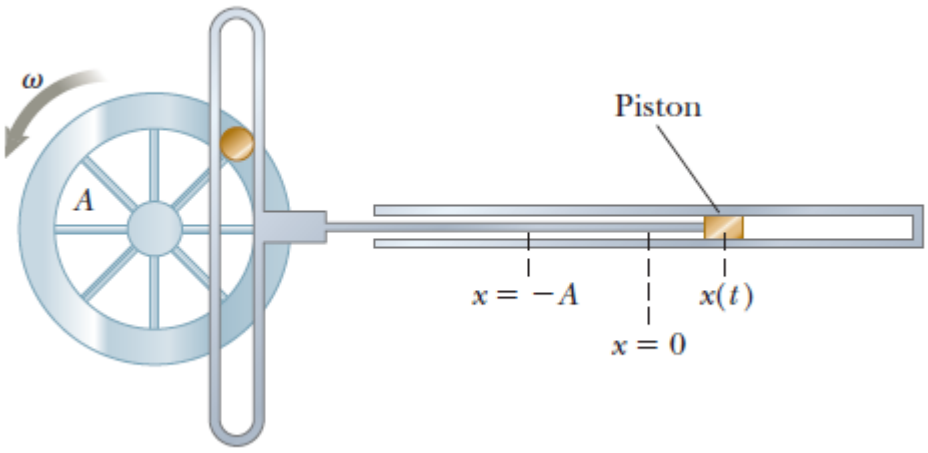


Figure 3

B6. Your phone alarm clock awakens you with a steady and irritating sound of frequency 600 Hz. One morning, on the day of exams, it malfunctions and cannot be

turned off. In frustration, you drop the phone out of your three-story hostel window, 15.0 m from the ground. Assume the speed of sound is 343 m/s. As you listen to the falling phone, calculate the frequency you hear just before you hear it striking the ground? **[3]**

B7. The displacement function for a pulse passing through a string is given by $D(x,t) = \frac{5.0}{6.0+(x-5.0t)^2}$ where $\boldsymbol{x}$ and $\boldsymbol{D}$ are in metres and $\boldsymbol{t}$ is in seconds.

a. Calculate the speed of the pulse, and in which direction is it travelling **[2]**

b. Calculate the displacement of a point located at $\boldsymbol{x = 2.0\,m}$ at $\boldsymbol{t = 3.0s}$ **[2]**

c. Calculate the maximum displacement of a point on the string **[2]**

d. Calculate the transverse speed of a point that is located at $\boldsymbol{x = 2.0\,m}$ at $\boldsymbol{t = 3.0s}$ **[2]**

e. Sketch a displacement versus position (x) graph for $\boldsymbol{t = 0s, 1s, 2s}$, and $\boldsymbol{3s}$ for this waveform **[2]**

SECTION C *(25 marks)*

Answer all questions.

C1. Three light rays simultaneously emitted by a candle pass through a converging lens, as shown in figure 4 below.

a. Which ray arrives at the screen first? **[2]**

b. Explain your answer to a **[3]**

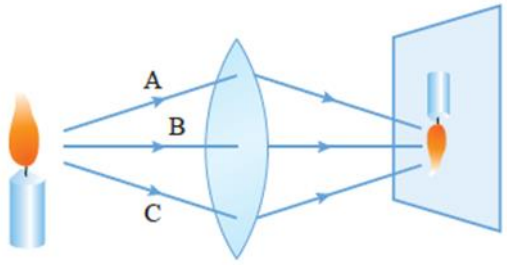


Figure 4

C2. A concave mirror has a focal length of 20 cm. An object is placed 30 cm away from the mirror. Determine the position, the size and the nature of the image formed by the mirror. Also, draw a ray diagram to show the image formation. **[4]**

C3. Referring to the circuit shown in figure 5 below, determine the number of.

a. nodes; **[1]**

b. elements; **[1]**

c. branches. **[1]**

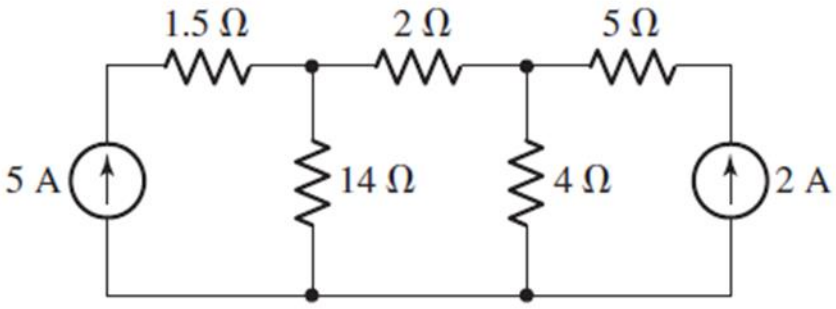


Figure 5

C4. Two-point charges of $+2\,\mu C$ and $-3\,\mu C$ are placed 10 cm apart in vacuum. Find the electric force between them and the electric field at the midpoint of the line joining them. **[3]**

C5. Electric eels generate electric pulses along their skin that can be used to stun an enemy when they encounter it. Research has shown that these pulses can be up to $500\,V$ and produce currents of $80\,mA$ (or even larger). A typical pulse lasts for $10\,ms$. Calculate:

a. The charge released, **[2]**

b. the power and, **[2]**

c. how much energy are delivered to the unfortunate enemy with a single pulse, assuming a steady current. **[2]**

C6. A straight wire of length 20 cm carries a current of 5 A. The wire is placed in a uniform magnetic field of 0.2 T that is perpendicular to the wire. Find the magnetic force on the wire and the magnetic flux through a rectangular loop of area $0.04\,m^2$ that encloses the wire. **[4]**

END OF EXAMINATION

SECTION A *(45 marks)*

Attempt ALL questions.

A1. Hooke's law states that the force, F, in a spring extended by a length x is given by $F = -kx$. From Newton's second law $F = ma$, where m is the mass and a is the acceleration, calculate the dimensions of the spring constant k in terms of mass (M), length (L) and time (T) **[3]**

A2. How many significant digits are in:

a) 23,000? **[2]**

b) 4000.00? **[2]**

c) 0.00023040? **[2]**

A3. A train increases its speed steadily from $10\ ms^{-1}$ to $20\ ms^{-1}$ in 2 minutes.

a) Calculate its average speed during this time, in m/s **[3]**

b) Calculate how far does it travel while increasing its speed **[4]**

c) Plot the trains velocity time graph **[3]**

A4. A ball is projected vertically upwards with an initial velocity of $40\ ms^{-1}$. Calculate.

a) Its maximum height and, **[3]**

b) The time taken to return to its starting point. **[3]**

Neglect air resistance and take $g = 10\ ms^{-2}$.

A5. A block of mass 500 g is pulled from rest on a horizontal frictionless bench by a steady force **F** and travels 8 m in 2 s. Find;

a) the acceleration, **[3]**

b) the value of **F**. **[3]**

A6. Draw a labelled diagram to show the forces acting on a skydiver falling with a constant velocity. **[4]**

A7. An elevator carries 11 passengers of average mass 70 kg to a height of 20 meters in one minute.

a) Calculate the work done in lifting the passengers **[3]**

b) Calculate the power needed to do that task **[3]**

A8. Two globes of identical mass and radius are spinning about axes through their centres at the same speed. One of the globes is a solid sphere, and the other has a hollow space at its centre. Which globe is easier to stop? Explain **[4]**

SECTION B *(30 marks)*

Answer any **All** questions.

B1. Calculate the difference in blood pressure (in atmosphere) between the heart. and the foot in a person of height 2.00 *m* and the height from the heart to the head is 0.40 *m* and the density of blood is $1.06 \times 10^3 kg/m$. **[3]**

B2. The U-shape in **Fig 1** contains two liquids in static equilibrium: water of density $998\ kgm^{-3}$ and an unknown liquid with unknown density. Find the density of the unknown liquid if $h = 155\ mm$ and $l = 135\ mm$. **[3]**

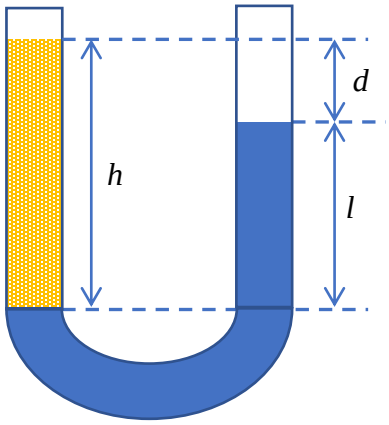


Fig 1

B3. Define floating. **[2]**

B4. A cube of edge length $L = 0.600\ m$ and mass $450\ kg$ is suspended by a rope in an open tank of liquid of density $1030\ kgm^{-3}$, as shown in **Fig 2**.

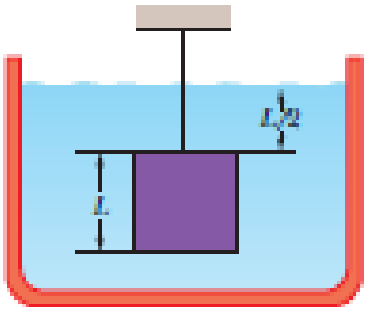


Fig 2

Find,

a) the magnitude of the total downward force on the top of the cube from the liquid and the atmosphere, assuming atmospheric pressure is 1.00 atm, **[2]**

b) The magnitude of the total upward force on the bottom of the cube, **[2]**

c) The tension in the rope. **[2]**

d) The magnitude of the buoyant force on the cube using Archimedes' principle. **[3]**

B5. A garden hose with an internal diameter of 1.9 cm is connected to a (stationary) lawn sprinkler that consists merely of a container with 24 holes, each 0.13 cm in diameter. If the water in the hose has a speed of 0.91 m/s, at what speed does it leave the sprinkler holes? **[3]**

B6. A block of mass $m = 14.00\ kg$ is released from rest on a frictionless incline of angle $\theta = 30°$, as shown in **Fig 3**. Below the block is a spring with spring constant, $k = 1800 N/m$. The block momentarily stops when it compresses the spring by 7.0 cm. Calculate the speed of the block just before compressing the spring. **[3]**

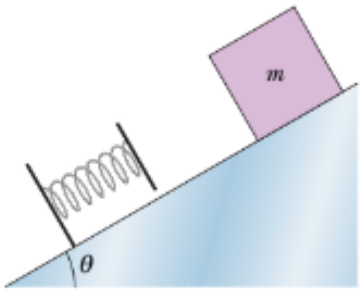


Fig 3

B7. A hypodermic syringe contains a medicine with the density of water (Fig.4). The barrel of the syringe has a cross-sectional area $A = 2.5 \times 10^{-5} m^2$, and the needle has a cross-sectional area $a = 1.0 \times 10^{-8} m^2$. In the absence of a force on the plunger, the pressure everywhere is $1.00\ atm$. A force $\vec{F}$ of magnitude $2.00\ N$ acts on the plunger, making medicine squirt horizontally from the needle. Determine the speed of the medicine as it leaves the needle's tip. **[4]**

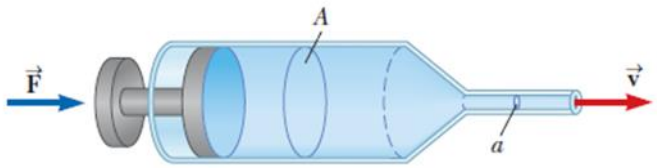


Fig 4

B8. A police siren emits a frequency of 700.0 Hz. When the police car approaches you at a speed of 80.0 km/h, what frequency do you perceive? **[3]**
(Take the value of the speed of sound in air to be $330 ms^{-1}$)

SECTION C *(25 marks)*

Answer any **All** questions.

C1. An observer is positioned so that the far edge of the bottom of an empty glass is just visible (Fig 5 below). When the glass is filled to the top with water, the centre of the bottom of the glass is just visible to the observer. The width of the glass is 4 cm.

(a) Determine the height, h, of the glass? **[5]**

(b) What does the observer see when the glass is filled with oil instead of water? **[2]**

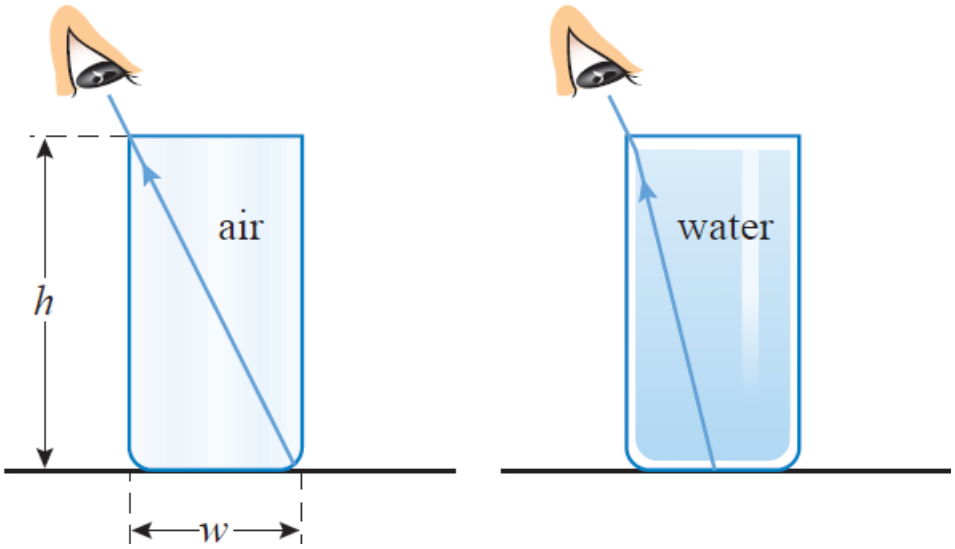


Fig 5

C2. A capacitor that has two parallel plates of dimensions 10.00cm ×7.50 cm separated by 1.50 mm of air is connected to a 24.0 V battery. Find

a) the capacitance **[3]**

b) the charge on one plate **[3]**

c) the electric field in the capacitor **[3]**

C3. Two long, parallel wires are separated by a distance of $4.50\ cm$. The force per unit length that each wire exerts on the other is $8 \times 10^{-5} N$ and the wires repel each other. The current in one wire is $0.750\ A$.

a) Calculate the current in the second wire? **[3]**

b) Are the two currents in the same direction or in opposite directions? **[2]**

C4. A 60W electric light bulb is connected to a 240V supply. Determine:

a) the current flowing in the bulb and **[2]**

b) the resistance of the bulb. **[2]**

END OF EXAMINATION

SECTION A *(40 marks)*

Attempt ALL questions.

A1. Show that the expression $v = at$, where v represents speed, a acceleration, and t an instant of time, is dimensionally correct in terms of mass (M), length (L) and time (T). **[3]**

A2. Define the following:

a) Precision **[1]**

b) Accuracy **[1]**

A3. When measuring the length of a room, independent measurements have established that the actual length of a room is $4.50\ m$. Your friends use the same metre stick and measure values from $4.45\ m$ to $4.56\ m$. Another friend uses an ultrasound rangefinder electronic device, reporting values from $4.405\ m$ to $5.014\ m$. Comment on the precision and accuracy of each type of measurement, and on the possibility of systematic errors. **[4]**

A4. One drop of oil falls straight down onto the road from the engine of a moving car every $5\ s$. Figure 1 shows the pattern of the drops left behind on the pavement. Determine the average speed of the car over this section of its motion **[4]**

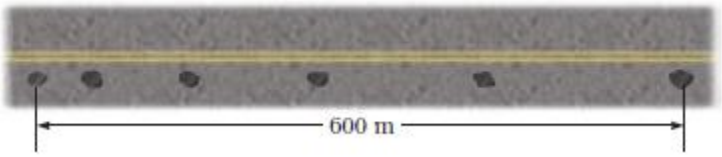


Figure 1

A5. An airplane flying horizontally at a constant speed of $350\ km/h$ over level ground releases a bundle of food supplies. Ignore the effect of the air on the bundle.

a) Determine the bundle's initial.

i. vertical and, **[2]**

ii. horizontal components of velocity **[2]**

b) Determine its horizontal component of velocity just before hitting the ground. **[3]**

c) If the airplane's speed were, instead, $450\ km/h$, would the time of fall be longer, shorter, or the same. **[3]**

A5. You have just had the apples in your orchard harvested into many boxes with a mass of $130.0\ kg$ each. You wish to lift these boxes up to the fourth floor ($12.0\ m$ above ground level) of your packaging facility. Since you are the only person available, you construct a slippery surface that is inclined $30.0°$ above the horizontal, and then fix a pulley at the top corner, as shown in Figure 2. You hang from the rope at the top of the incline and let the force of gravity pull the crates up the ramp. The friction between the crates and the inclined surface is negligible.

a) Determine the minimum mass you should be for this system to work **[3]**

b) If you do not wish to hit the ground with a speed greater than $2.00\ m/s$, determine what your maximum should mass be. **[3]**

c) Calculate how long it will take to lift one crate to the fourth floor if you have the mass calculated in part (b) **[3]**

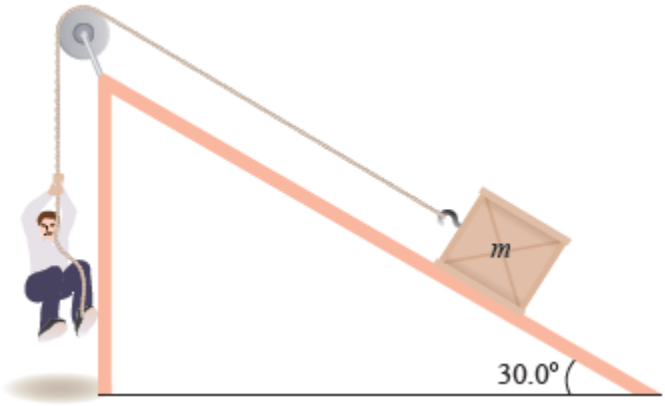


Figure 2

A6. A man cleaning a floor pulls a vacuum cleaner with a force of magnitude $F = 50.0\ N$ at an angle of $30.0°$ with the horizontal (Figure 3). Calculate the work done by the force on the vacuum cleaner as the vacuum cleaner is displaced $3.00\ m$ to the right. **[4]**

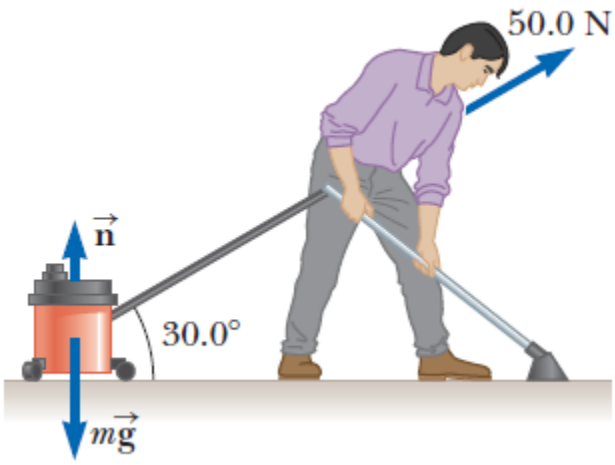


Figure 3

A8. A $10.0g$ bullet is fired into a stationary block of wood having mass $m = 5.00\ kg$. The bullet imbeds into the block. The speed of the bullet-plus-wood combination immediately after the collision is $0.600\ m/s$. Determine the original speed of the bullet. **[4]**

SECTION B *(35 marks)*

Answer question **B1** and **any other three** questions.

B1. A $0.250kg$ block resting on a frictionless, horizontal surface is attached to a spring whose force constant is $83.8\,N/m$ as in Figure 4. A horizontal force $\vec{F}$ causes the spring to stretch a distance of $5.46\,cm$ from its equilibrium position.

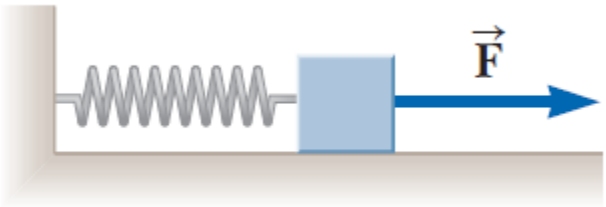


Figure 4

a) Calculate the magnitude of $\vec{F}$ **[3]**

b) Calculate the total energy stored in the system when the spring is stretched. **[4]**

c) Determine the magnitude of the acceleration of the block just after the applied force is removed. **[4]**

d) Determine the speed of the block when it first reaches the equilibrium position. **[3]**

B2. i. Calculate the pressure increase in the fluid in a syringe when a nurse applies a force of $42N$ to the syringe's circular piston, which has a radius of $1.1\,cm$. **[2]**

ii. A $6100\,kg$ rocket is set for vertical firing from the ground. If the exhaust speed is $1200\,m/s$, calculate the quantity of gas that must be ejected each second if the thrust.

a) is to equal the magnitude of the gravitational force on the rocket and **[2]**

b) is to give the rocket an initial upward acceleration of $21\,ms^{-2}$. **[3]**

B3. A glass tube of cross-sectional area $1.0 \times 10^{-4}\,m^2$ is partially filled with water. An oil with a density of $800\,kgm^{-3}$ is slowly poured into the tube so that it does not mix with the water and floats on top of it. The height of the oil above the water surface is $8cm$.

a) Calculate the change in pressure at a depth of $10\ cm$ below the water surface. **[3]**

b) Would the pressure at this depth increase or decrease if you added more oil to the tube. **[2]**

c) With aid of diagrams or sketches, explain your answer in b) **[2]**

B4. i. The intake duct in Figure 5 has cross-sectional area of $0.74\ m^2$ and water flow at $0.40\ m/s$. At the outlet, distance $D = 180\ m$ below the intake, the cross-sectional area is smaller than at the intake and the water flows out at $9.5\ m/s$ into equipment. Determine the pressure difference between inlet and outlet. **[3]**

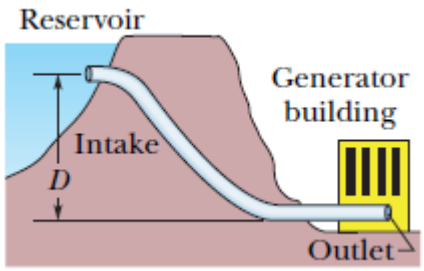


Figure 5

ii. A submarine (sub-A) travels through water at a speed of $8.00\ m/s$, emitting a sonar wave at a frequency of $1\,400\ Hz$. The speed of sound in the water is $1\,533\ m/s$. A second submarine (sub-B) is located such that both submarines are traveling directly toward each other. The second submarine is moving at $9.00\ m/s$. Calculate the frequency which is detected by an observer riding on sub–B as the subs approach each other. **[4]**

B5. In an electric shaver, the blade moves back and forth over a distance of $2.0\ mm$ in simple harmonic motion, with frequency $120\ Hz$. Find

a) the amplitude, **[2]**

b) the maximum blade speed, and **[3]**

c) the magnitude of the maximum blade acceleration. **[3]**

B6. The speed of sound in air is $340.0\ m/s$. The angular frequency of a sound wave is $600.0\ rad/s$. Determine the waves.

a) frequency **[3]**

b) period **[2]**

c) wavelength **[2]**

SECTION C *(25 marks)*

Answer question **C1 and any other three** questions.

C1. A capacitor that has two parallel plates of dimensions 10.00cm ×7.50 cm separated by 1.50 mm of air is connected to a 24.0 V battery. Find

a) the capacitance **[2]**

b) the charge on one plate **[2]**

c) the electric field in the capacitor **[3]**

C2. On a car's side-view mirror you notice a warning: "Objects in mirror are closer than they appear."

a) With the aid of sketches and diagrams, explain the physics behind that statement. **[3]**

b) What type of mirror is it, and why is it used as a side-view mirror. **[3]**

C3. A coin is placed at the bottom of an $80.0\ cm$ deep aquarium filled with water. You are looking at the coin from above the aquarium.

a) Explain, using ray diagrams and the necessary calculations, how deep will the coin appear to you. **[6]**

C4. A narrow beam of light is incident on an air–glass boundary at an angle of $30°$.

a) Calculate the angle of deflection (the angle between the incident and refracted beams) of this beam. **[3]**

b) Will the angle of deflection increase or decrease when the angle of incidence increases to $45°$, Justify your answer with calculations and a diagram. **[3]**

C5. A wire made of a manganese alloy has a length of 56 cm and a diameter of 0.40 mm. The resistivity of the alloy is $\rho = 0.45\ \mu\Omega\text{m}$.

a) Find the resistance of the wire. **[3]**

b) Find the current through the wire when the potential difference across it is 3.0 V. **[3]**

END OF EXAMINATION

SECTION A *(50 marks)*

A1. A train increases its speed steadily from $10\ m/s$ to $20\ m/s$ in 2 minutes.

a. Calculate its average speed during this time, in m/s **[3]**

b. Calculate how far does it travel while increasing its speed **[4]**

c. Plot the trains velocity time graph **[3]**

A2. Determine the vector product of these two vectors.

$$\vec{\mathbf{A}} = -2\hat{i} + 3\hat{j} + 4\hat{k}$$

$$\vec{\mathbf{B}} = 3\hat{i} + \hat{j} - 3\hat{k}\ . \quad \textbf{[3]}$$

A3. A stone is projected at a cliff of height *h* with an initial speed of 42.0 *m/s* directed at angle $\theta = 60.0°$ above the horizontal as shown in Fig 1 below. The stone strikes at *A*, 5.50 *s* after launching.

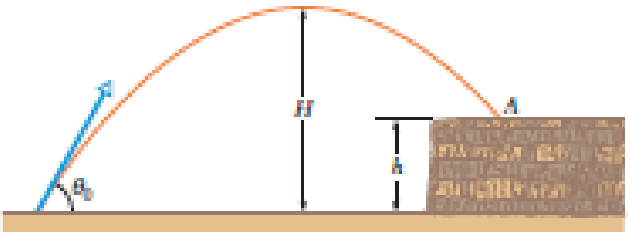


Fig 1

Find

(i) the height h of the cliff **[2]**

(ii) the speed of the stone just before impact at A, **[3]**

(iii) the maximum height H reached above the ground. **[2]**

A4. A crate of mass $m = 55\ kg$ is pushed at constant speed up a ramp inclined at 35.0° by a horizontal force as shown in Fig. 2.

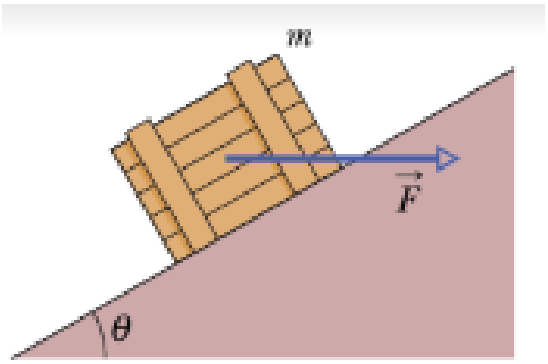


Fig. 2.

If the ramp has a coefficient of friction, $\mu = 0.05$

a. Calculate the magnitude of the normal force **[3]**

b. Calculate the force $\vec{F}$ **[2]**

A5. An elevator carries 7 passengers of average mass 70 kg to a height of 20 meters in one minute.

a. Calculate the work done in lifting the passengers **[5]**

b. Calculate the power needed to do that task **[5]**

A6. Explain what you understand by the term *elastic collision*. **[2]**

b) A body of mass $3.0\ kg$ makes an elastic collision with another body at rest and continues to move in the original direction but with one-fourth of its original speed. Calculate the mass of the other body. **[4]**

A7. A block whose mass m is 750 g is fastened to a spring whose spring constant k is $55\ N/m$ (Fig 3.). The block is pulled a distance $x = 5$ cm from its equilibrium position at $x = 0$ on a frictionless surface and released from rest at $t = 0$.

a. What are the angular frequency, the frequency, and the period of the resulting motion? **[3]**

b. What is the amplitude of the oscillation? **[2]**

c. What is the maximum speed v_m of the oscillating block, and where is the block when it has this speed? **[2]**

d. What is the magnitude a_m of the maximum acceleration of the block? **[2]**

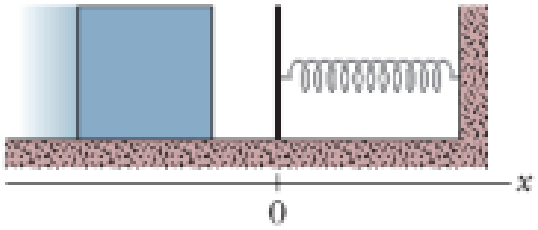


Fig 3.

SECTION B *(30 marks)*

Answer all questions

B1. State

a. Pascal's Law **[2]**

b. Archimedes Principle **[2]**

B2. Give an example of an application of Bernoulli's principle in engineering or everyday life. **[3]**

B3. Explain what you understand on Archimedes' principle and how can it be used to determine the buoyant force on an object submerged in a fluid? **[4]**

B4. A bloc of density 4000kg/m^3 and volume of 0.004m^3 is immersed in water (density 1000kg/m^3). Calculate:

a. The upward force exerted by the fluid on the object **[3]**

b. The weight of the object in air **[3]**

c. Its weight inside the fluid **[3]**

B5. The displacement function for a pulse travelling along a string is given by the equation

$$D(x,t) = \frac{4.0}{(x-2t)^2 + 6.0}$$

where *x* is in metres and *t* is in seconds.

a. Determine the speed of the pulse, and the direction in which is it travelling **[2]**

b. Calculate the displacement of a point located at $x = 4.0\ m$ at $t = 1.0\ s$ **[3]**

c. Calculate the speed of a point that is located at $x = 5.0\ m$ at t=1.0 s **[3]**

d. Determine the maximum displacement of a point as the pulse passes through it. **[2]**

SECTION C *(20 marks)*

Answer all questions

C1. Using sketches, were necessary, explain Kirchhoff's current Law. **[2]**

C2. Using sketches were necessary, explain Kirchhoff's Voltage Law **[2]**

C3. Referring to the circuit shown below (Fig. 4), determine the number of.

a. branches **[1]**
b. nodes **[1]**
c. loops **[1]**

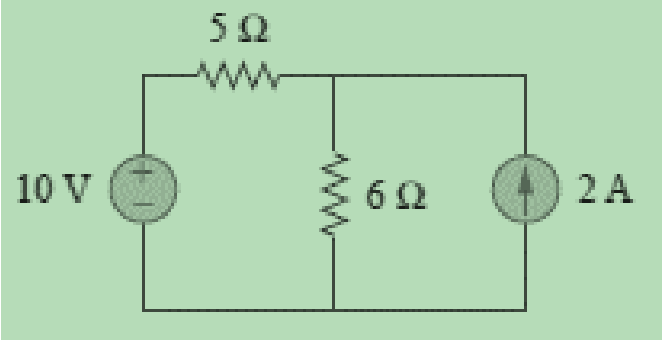


Fig 4.

C4. A $+30.0\ nC$ charge is placed at the origin of a coordinate system, and a $-50.0\ nC$ charge is placed in the xy-plane at the point$(x = 0.100\ m, y = -0.500\ m)$.

a) Determine the magnitude and the direction of the force that the positive charge exerts on the negative charge. Use ijk notation for your result. **[3]**

b) Determine the magnitude and direction of the force of the negative charge on the positive charge. **[3]**

C5. Electric eels generate electric pulses along their skin that can be used to stun an enemy or prey when they come into contact with it. Research has shown that these pulses can be up to 500 V and produce currents of 80 mA (or even larger). A typical pulse lasts for 10 ms. Calculate:

a) The charge released, **[2]**

b) the power and, **[2]**

c) how much energy are delivered to the unfortunate enemy with a single pulse, assuming a steady current. **[3]**

END OF EXAMINATION

SECTION A *(45 marks)*

Attempt ALL questions.

A1. Explain why the Engineering Physics Course is relevant to your area of study. **[3]**

A2. Hooke's law states that the force, F, in a spring extended by a length x is given by $F = -kx$. From Newton's second law $F = ma$, where m is the mass and a is the acceleration, calculate the dimensions of the spring constant k. **[3]**

A3. Suppose that the uncertainty in the length $17.386\ 22\ m$ is $0.04\ m$. Round the length to the correct number of significant digits. **[2]**

A4. A female cheetah starts from rest and accelerates uniformly for 5 seconds until she reaches a velocity of $20\ m\ s^{-1}$while chasing a Thompson gazelle. She then runs at a constant velocity for 8 seconds before decelerating as she failed to catch the gazelle. Sketch a velocity-time graph of her motion. **[4]**

A5. A construction worker standing on a beam asks his very strong friend on the ground 9.00 m below to throw his lunch box up to him. The friend wants to throw the box straight up such that it has a velocity of 0.500 m/s up when it reaches the worker on the beam, to give him some leeway as he tries to catch it.

b) What assumption(s) should you make to solve the problem? **[2]**

c) At what speed should the friend throw the lunch box? **[3]**

d) How long will the lunch box be in the air before it is caught by the worker? **[2]**

e) How long does it take for the lunch box to cover the first 4.50 m of its trajectory? **[3]**

f) How high above its initial position will the lunch box be after half the total time of its motion? **[2]**

g) Sketch the distance-time, velocity-time, and acceleration-time graphs for the motion of the lunch box. **[4]**

A6. Two objects are moving at constant velocities: $\vec{V}_A = (2\hat{\imath} - 5\hat{\jmath})m/s$, $\vec{V}_B = (-2\hat{\imath} + 4\hat{\jmath})m/s$.

a) Which object is moving faster? **[3]**

b) Find the angle between objects' trajectories. **[3]**

A7. In Fig 1. a block of mass m_1 = 1.5 kg (**A)** on a plane inclined at $\theta = 30°$ (coefficient of friction = 0.15) is connected by a cord over a frictionless pulley to a second block **B** of mass m_2 = 3.00kg. Ignoring the mass of the pulley, determine

a) the magnitude of the acceleration of each block, **[4]**

b) the direction of the acceleration of the hanging block, and **[1]**

c) the tension in the cord. **[2]**

d) If the blocks are released from rest with the connecting cord taut, use the work kinetic energy theorem to determine the blocks total kinetic energy when block B has moved 30cm. **[4]**

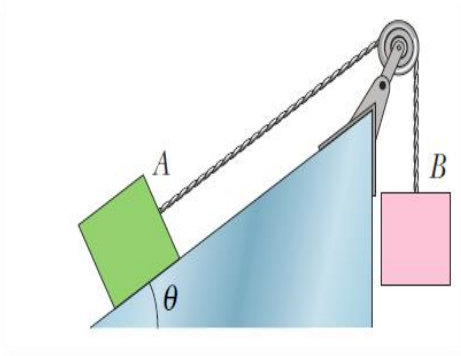


Figure 1

SECTION B *(35 marks)*

Answer question **B1** and **any other three** questions.

B1. (a) Define floating. **[2]**

(b) A cube of edge length $L = 0.600\,m$ and mass $450\,kg$ is suspended by a rope in an open tank of liquid of density $1030\,kg/m^3$, as shown in Fig 2.

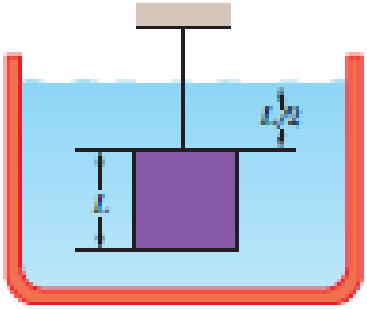


Figure 2

Find,

(i). the magnitude of the total downward force on the top of the cube from the liquid and the atmosphere, assuming atmospheric pressure is 1.00 atm, **[2]**

(ii). The magnitude of the total upward force on the bottom of the cube, **[2]**

(iii). The tension in the rope. **[2]**

(iv). The magnitude of the buoyant force on the cube using Archimedes' principle. **[3]**

B2.

a) Define resonance and describe one scenario where it is applied for the benefit of mankind. **[4]**

b) A block of mass $m = 14.00\,kg$ is released from rest on a frictionless incline of angle $\theta = 30°$, as shown in **Fig 3**. Below the block is a spring with spring constant, $k = 1800N/m$. The block momentarily stops when it compresses the spring by 7.0 cm. Calculate the speed of the block just before compressing the spring. **[4]**

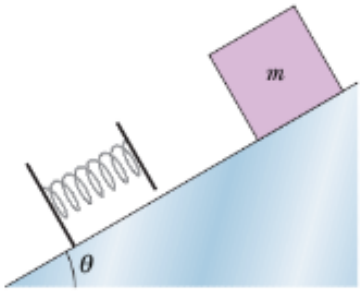


Figure 3

B3. (a). Calculate the difference in blood pressure (in atmosphere) between the heart and the foot in a person of height 2.00 *m* and the height from the heart to the head is 0.40 *m* and the density of blood is $1.06 \times 10^3 kg/m$. **[4]**

(b). The U-shape in Fig 4 contains two liquids in static equilibrium: water of density $998\ kg/m^3$ and an unknown liquid with unknown density. Find the density of the unknown liquid if $h = 155\ mm$ and $l = 135\ mm$. **[4]**

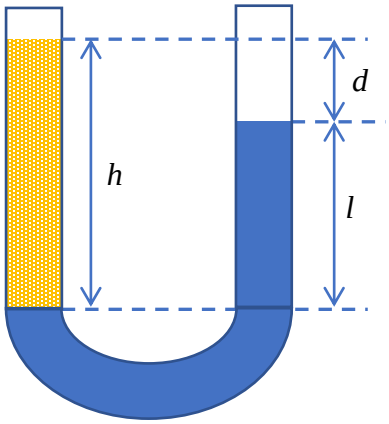


Figure 4

B4. A bat is flying at 7.00 m/s and is emitting cries at a frequency of 82.0 kHz. It is chasing a moth and is detecting the echoes from the moth. Moths fly somewhat erratically. Calculate the frequency detected by the bat when the moth is;

a) Stationary **[2]**

b) flying at 1.00 m/s in the same direction as the bat **[3]**

c) flying at 2.00 m/s toward the bat **[3]**

B5.

a) You went to the farm to do some sightseeing, then the workers ask you to measure the depth of a well. As an engineering student, you decide to show that you can use your intellect to determine the depth of the well to the amusement of the folks there. You drop a stone into the well and hear the splash 2.8 s later. Calculate the depth of the well. **[4]**

b) Consider the simplified single-piston engine in Fig 5. Assuming the wheel rotates with constant angular speed, explain why the piston rod oscillates in simple harmonic motion. **[4]**

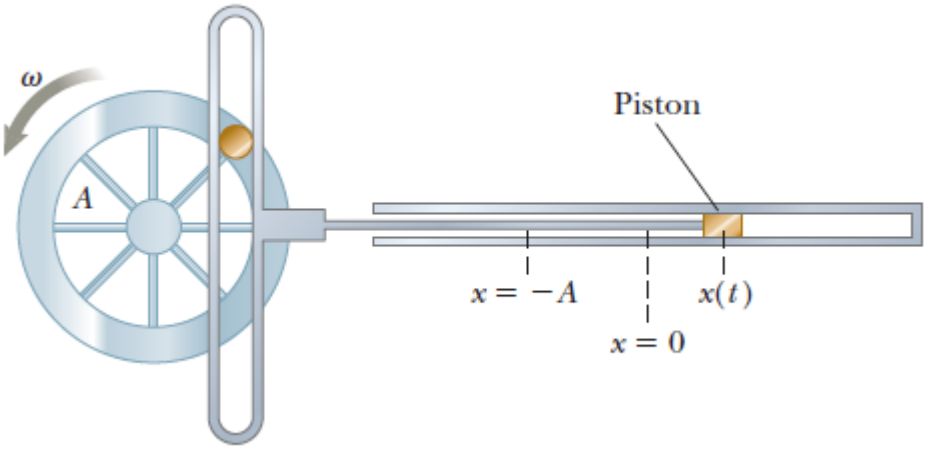


Figure 5

SECTION C *(20 marks)*

Answer question **C1 and any other three** questions.

C1. Draw a diagram showing the effects of both a converging lens on a beam of parallel rays. On the diagram clearly label the principle axis, principle focus, and focal length. **[8]**

C2. Good electrical conductors, such as metals, are typically good conductors of heat; electrical insulators, such as wood, are typically poor conductors of heat. Explain why there should be a relationship between electrical conduction and heat conduction in these materials. **[4]**

C3. An underwater scuba diver sees the Sun at an apparent angle of $45.0°$ above the horizontal. Calculate the actual elevation angle of the Sun above the horizontal. **[4]**

C4. A $+35.0\,nC$ charge is placed at the origin of a coordinate system, and a $-25.0\,nC$ charge is placed in the xy-plane at the point$(x = 0.100\,m, y = -0.0500\,m)$.

a) Determine the magnitude and the direction of the force that the positive charge exerts on the negative charge. Use ijk notation for your result. **[4]**

C5. A Referring to the circuit shown below in Fig 6, determine the number of;

a) nodes; **[1]**

b) elements; **[1]**

c) branches. **[1]**

d) loops **[1]**

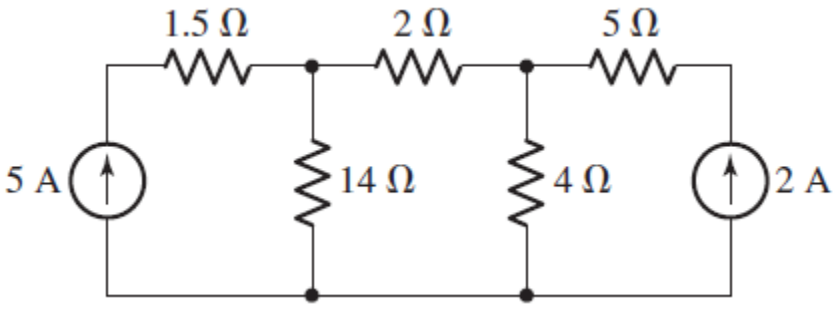


Figure 6

END OF EXAMINATION

SECTION A: NEWTONIAN MECHANICS *(50 marks)*

Attempt **ALL** questions.

A1.

a) Explain the significance of precision and accuracy in experimental measurements. **[2]**

b) A vector $\vec{A}$ has components $Ax = 4.0\,m,\ Ay = 3.0\,m$. Calculate its magnitude and direction. **[4]**

c) Use dimensional analysis to check the correctness of the equation $v = \sqrt{2gh}$ **[3]**

d) Compare the uncertainties in measurements from vernier calipers and micrometer screw gauge. **[4]**

A2. A car accelerates uniformly from rest and covers 100 m in 8 seconds.

(a) Determine the car's acceleration. **[2]**

(b) Calculate its final speed. **[2]**

(c) Sketch a displacement time graph for the motion of the car. **[2]**

(d) A 10 kg object is acted on by a 50 N force. Calculate its acceleration and comment on the type of force involved. **[4]**

(e) Define terminal velocity and discuss any two factors affecting it. **[4]**

A3.

a) Define work and explain the conditions under which work is said to be zero. **[2]**

b) A spring of constant k = 200 N/m is compressed by 0.1 m. Calculate the potential energy stored. **[2]**

c) A 5 kg block slides 3 m down a 30° incline with negligible friction. Determine:

i) Work done by gravity **[2]**

ii) Final speed if it starts from rest **[3]**

iii) Energy conservation **[4]**

A4.

a) State the law of conservation of linear momentum. **[2]**

b) Two objects (2 kg at 4 m/s and 3 kg at rest) collide inelastically. Determine their common velocity after collision. **[4]**

c) Explain the difference between elastic and inelastic collisions using examples. **[4]**

SECTION B: FLUIDS, OSCILLATIONS, WAVES & MATERIALS SCIENCE

(30 marks)

Answer **any three** questions.

B1.

a) State Bernoulli's principle and describe its application in airplane wing design. **[4]**

b) Water flows in a horizontal pipe from a 6 cm to a 3 cm diameter. If the speed in the larger section is 2 m/s, calculate the speed in the narrow section. **[3]**

c) Explain how hydraulic brakes use Pascal's principle. **[3]**

B2.

a) Define simple harmonic motion and write its general equation. **[3]**

b) A 0.5 kg mass is attached to a spring of k = 20 N/m. Find the period of oscillation. **[3]**

c) Discuss two real-life applications of Simple Harmonic Motion (SHM). **[4]**

B3.

a) Define wave speed and write its relation to frequency and wavelength. **[2]**

b) A sound wave has a frequency of 500 Hz and travels at 340 m/s. Find its wavelength. **[2]**

c) Explain the Doppler effect and calculate the frequency heard by a stationary observer when a car moving at 25 m/s emits a horn at 600 Hz. **[6]**

B4.

a) Classify materials into metals, ceramics, and polymers with examples. **[3]**

b) Explain how grain structure affects strength in metals. **[3]**

c) Compare the mechanical properties of a metal and a polymer under tension. **[4]**

SECTION C: LIGHT, ELECTRICITY & MAGNETISM *(20 marks)*

Answer **any two** questions.

C1.

a) State Snell's Law. Light moves from air ($n = 1$) to glass ($n = 1.5$) at 45°. Determine the angle of refraction. **[3]**

b) Explain the working principle of a convex lens with a ray diagram. **[4]**

c) Name two applications of lenses in engineering. **[3]**

C2.

a) Define Coulomb's law and calculate the force between two $1\ \mu C$ charges placed $0.2\ m$ apart. **[3]**

b) Explain how Kirchhoff's current law is applied at a node in a circuit. **[2]**

c) For a $12\ V$ battery connected to a $6\ \Omega$ and $3\ \Omega$ resistor in parallel, find the total current drawn. **[5]**

C3.

a) What is a magnetic field? Describe how to increase the strength of a solenoid's field. **[3]**

b) A coil of 100 turns carries $2\ A$ and has length $0.5\ m$. Calculate the magnetic field inside it. ($\mu_0 = 4\pi \times 10^{-7}\ T \cdot m/A$) **[4]**

c) State one engineering application each of a solenoid and an electromagnet. **[3]**

END OF EXAMINATION